POWER PLANT ENGINEERING

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The New Hammermill Plant

PAPER MILL INSTALLATION EMPLOYS SUPERHEATED STEAM FOR BOTH PRIME MOVER OPERATION AND MANUFACTURING PROCESSES

IN THE PROCESS of making paper, not only is a great deal of electric energy required for the operation of the many large pieces of machinery generally found in mills devoted to this kind of work and the lighting of the buildings —operation usually being on a 24-hr. basis—but also enormous quantities of steam and water. Accordingly, where there are paper mills one must of necessity find power plants and, as a rule, plants equipped to render all of the services demanded. An example of such an installation designed and built according to present day practice is the new power house operated in conjunction with the mill of the Hammermill Paper Co. located near the eastern outskirts of the city of Erie, Pa.

Shown in Fig. 2 is an exterior view of this plant which, as may be seen, has been built directly along the water's edge of Lake Erie upon a substantial foundation of solid rock. The structure consists essentially of a boiler house and a turbine room and occupies a ground space of approximately 117 by 90 ft.; it is built up of steel and concrete and is faced with brick of a dark red color. All floors are of concrete and steel, the latter painted black, thus giving to the whole a very pleasing and harmonious appearance.

Boiler house and turbine room floors are at like elevations with a basement below each having a head room

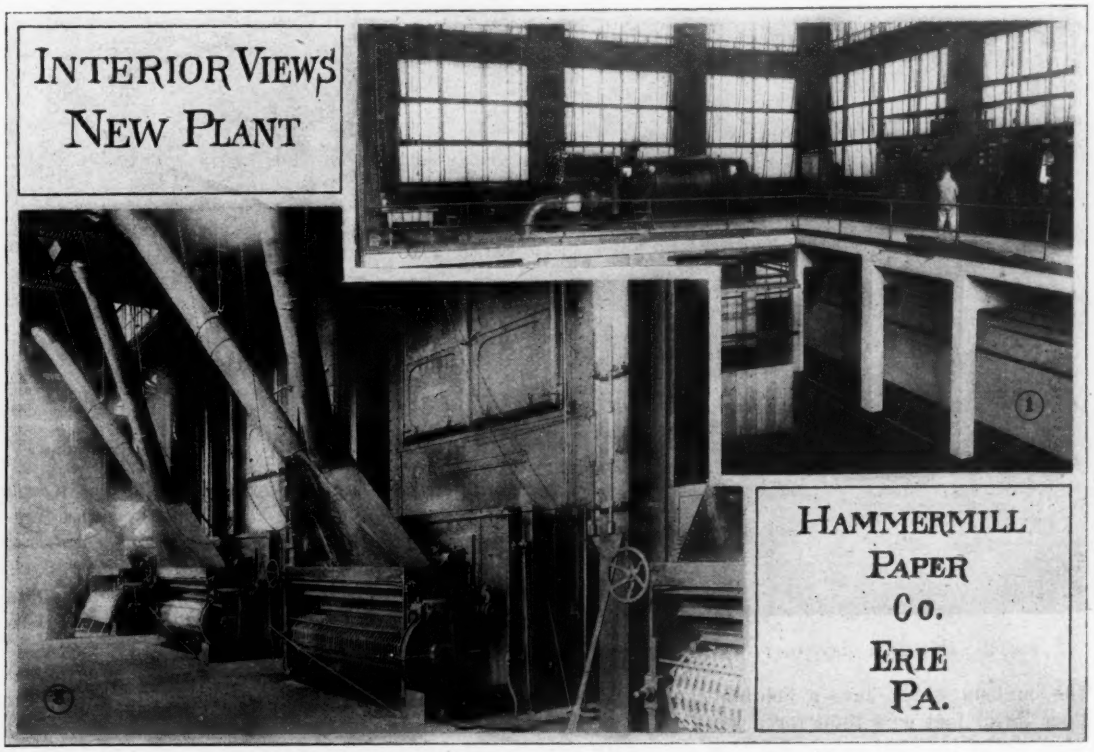

FIG. 3. INTERIOR OF BOILER ROOM

FIG. 1. TURBINE ROOM OF HAMMERMILL PLANT

of approximately 13 ft. Below the boiler room this space is given over to some of the auxiliary plant and ash handling equipment while the condensing and electric switching apparatus is found installed in the basement of the turbine room.

Large windows fitted with swinging sash and placed in each of the outside walls provide an excellent degree of natural illumination.

Handling Fuel and Ashes

Under ordinary conditions of operation and when this is available Pittsburgh slack is the fuel burned in the furnaces under the boilers. Location of the plant at the foot of a bluff has rendered possible a coal handling system of extreme simplicity. The cars in which the coal is brought to the plant are placed on tracks directly above the boiler room bunkers, the arrangement of the scheme employed being illustrated in Fig. 5, showing a cross-section through the power house and Fig. 2 an exterior view of the station from the lake.

FIG. 2. EXTERIOR VIEW OF POWER HOUSE

The bunkers which have a holding capacity of six tons per lineal foot or a total for a length of 88 ft. of 528 tons are of the steel suspended type lined with tile laid on an especially prepared enamel. Chain-operated gate valves allow feeding the stoker hoppers through the medium of chutes having lengths of about 20 ft.

Chain grate stokers operated by either one of two small upright simple engines placed on the floor of the boiler room are used in connection with the steam generating units. The discharge from these is dumped into reinforced concrete pits emptying into small dump cars run on tracks along the floor of the boiler room basement. Final disposal is by means of a skip hoist which deposits the ashes in an overhead bunker from where they are periodically removed.

Furnace gases are carried to the atmosphere through a sheet-metal breeching having sectional dimensions of approximately 8 by 9 ft. and connecting with a radial brick stack having a height of 250 ft. above the grates, 269 ft. above the ground and an internal diameter at the top of 9 ft. 6 in. Uptake dampers are under automatic steam pressure control.

Steam Generation and Distribution

Four 509-hp. water-tube boilers, each built for 250 lb. gage—but ordinarily operated at 235 lb. gage—and

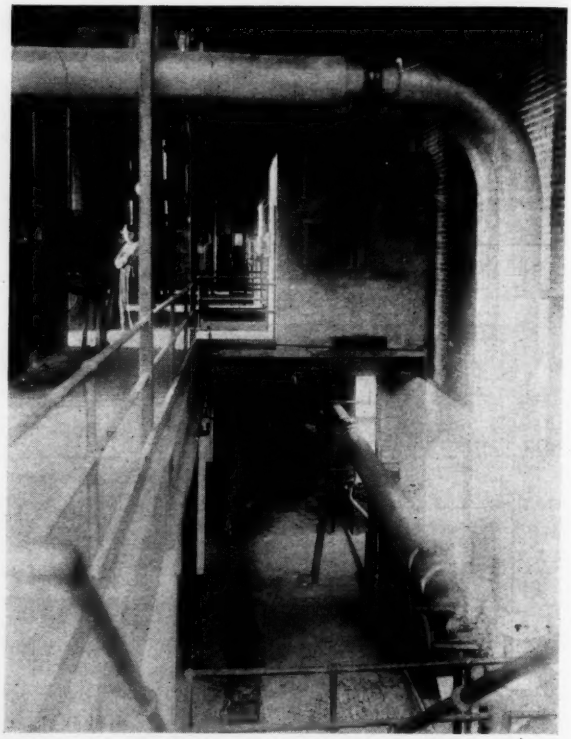

FIG. 4. VIEW ALONG REAR OF BOILERS

equipped with superheaters for raising the temperature of the steam 150 deg. F. above that corresponding to the pressure, comprise the steam-generating equipment. As a rule, and when operating conditions permit so doing, these units are worked at 175 per cent of their rated capacity, a loading found to provide the greatest overall economy.

Each of the boilers has been provided with CO_2 indicators, steam flow meters, flue gas temperature recorders and a full complement of draft gages.

The feed water made up of returns from the mill (temperature range 120 to 180 deg. F.) is heated in a heater of the open metering type nominally rated at 2000 hp. and then delivered to the boilers by either a centrifugal pump or an outside-packed plunger type of pump, actual feeding to the boilers, however, being under the control of automatic regulators.

Steam is carried from the boiler through 6-in. leads —each fitted with a non-return and a gate valve of like

size to a 10-in. header installed below the floor of the boiler room in the manner indicated in Fig. 5. Turbine supply branches are each 8 in. in diameter; an 8-in. mill line connects with the header at one end.

Saturated steam is also available and is used for the operation of such auxiliaries as the stoker engines, pumps, etc. This is delivered through 2-in. leads to a

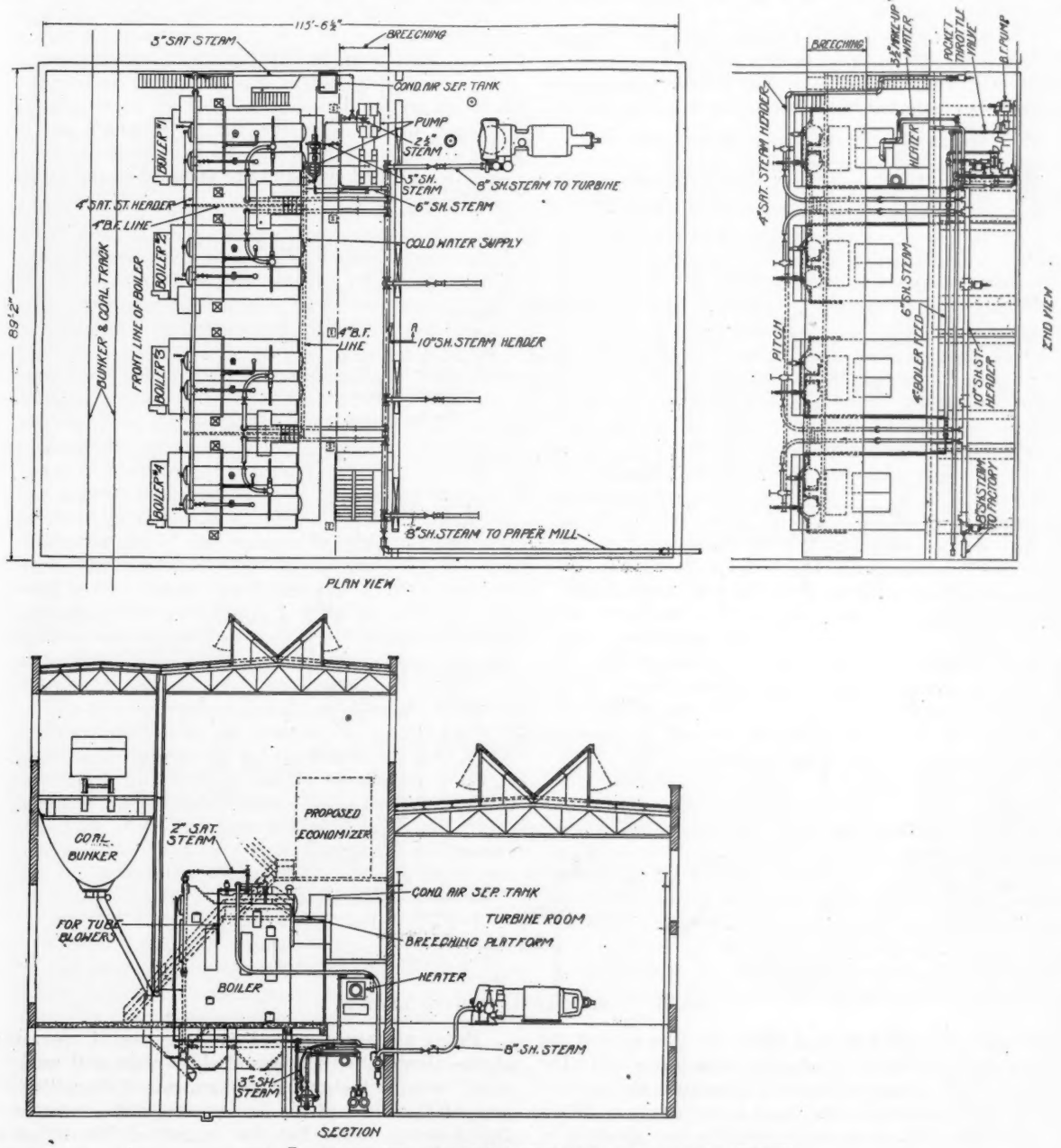

FIG. 5. PLAN AND SECTIONAL ELEVATIONS OF POWER HOUSE

saturated steam header 4 in. in diameter carried along the top of the boiler fronts.

Figure 5 illustrates the general arrangement of water and high-pressure steam piping employed.

In the Turbine Room

Although space has been provided for three units but one electric generating set has been installed up to the present time. This is a condensing turbo-generator rated at 2000 kv.a., 2300-v., 60 cycles, three-phase equipped with an 18-kw. direct-connected exciter. An auxiliary motor-driven exciter is to be installed shortly.

The condensing equipment which has been placed directly below the turbine consists of a rectangular type surface condenser containing 3000 sq. ft. of condensing surface made up of 1-in. No. 18 gage solid drawn brass tubes 12½ ft. long. The combined air and condensate pump is of the hydraulic type and is direct-connected to and driven by a 30-hp. steam turbine at a speed of 3600 r.p.m., while for handling the circulating water a 14-in. double-suction, bronze-fitted horizontally-split casing type pump designed to care for 4500 gal. of water per minute against a total head of 16 ft. and driven by a

30-hp. electric motor at a speed of 600 r.p.m. has been installed.

Placed between the turbine exhaust connection and the condenser inlet is a corrugated copper expansion joint and a tee which ties in with a 20-in. atmospheric exhaust valve for the relief of any excess back pressure apt to be established. The opposite side of the atmospheric exhaust valve connects directly with the 28-in. main exhaust header.

Cooling water is supplied to the condenser through a 16-in. line; this is again carried away by means of a 24-in. cold water waste line. The general scheme employed is as indicated in the accompanying illustrations.

Steam System Pressure Regulation

As shown in Fig. 5, one end of the 10-in. main superheated steam header connects through the medium of a gate valve with an 8-in. line which supplies part of the steam required for manufacturing work in the mill. The balance of the steam is furnished by another older plant; all of this is, however, distributed at a pressure of 160 lb.

Control of the pressure between the two plants is by means of two balanced valves actuated by two independent regulators, one of which is connected in on the 250-lb. side and arranged to shut the balanced valve on that supply line should the high pressure drop below 200 lb. The other regulator is connected in on the low-pressure side of the line and arranged to close should the pressure exceed 165 lb. This arrangement is employed in order that the turbine in the new power plant may be allowed to operate under only high-pressure steam and thus maintain the highest degree of economy on this unit.

The second regulator is employed primarily as a safety device to prevent the carrying of a pressure in excess of that for which the lines and the apparatus in the main portion of the mill are designed.

Electric Distribution and Load

Current from the generating unit is delivered to the generator panel of the switchboard shown at the right of Fig. 1. This board is built up of 13 panels, three of which are machine panels, five are feeder panels while the others are for the control of the lighting circuits, the automatic voltage regulator, the turbo-exciter and the motor exciter to be installed. All switches are of the oil manually operated type and are installed in the turbine room basement.

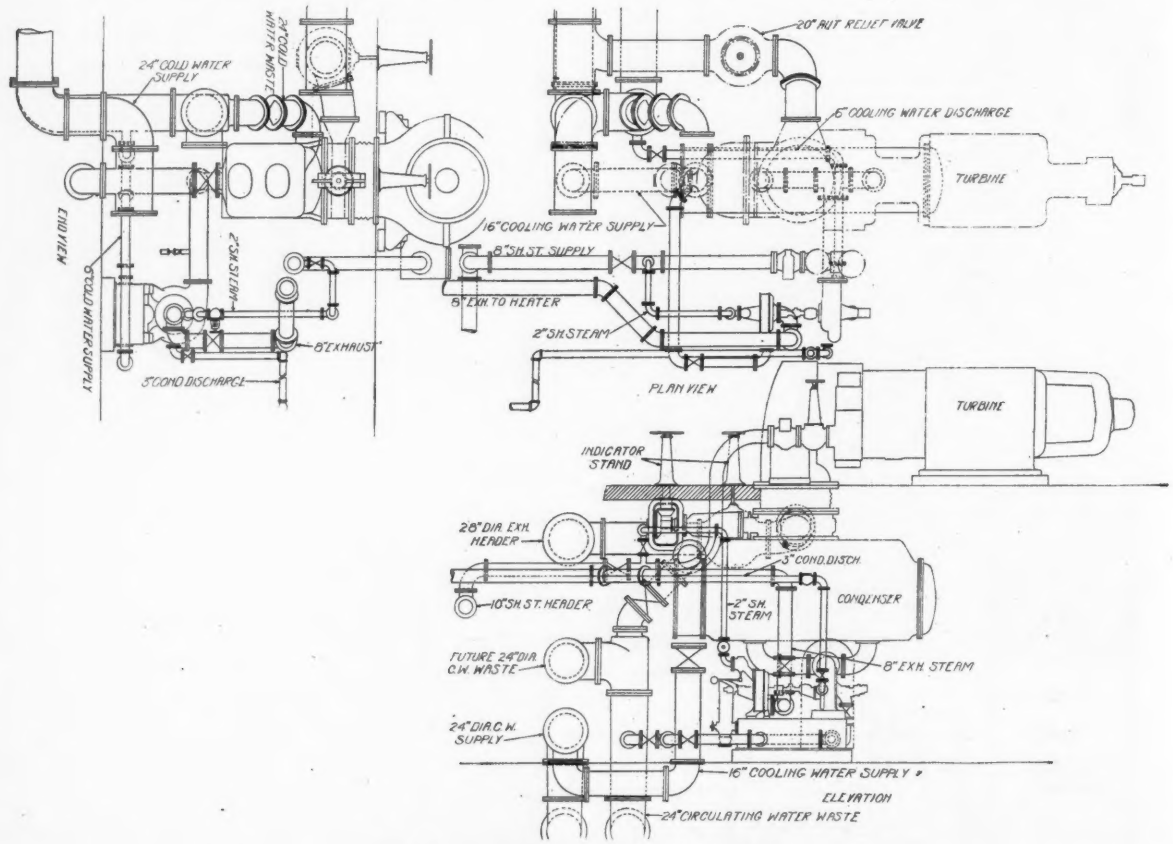

FIG. 6. CONDENSER AND PIPING LAYOUT

Means are also provided for the parallel operation of this plant with another and older plant still used to supply some of the service requirements of the mills and the 11,000-v. lines of the local central-station company. Due, however, to the fact that current at this station is generated at 2300 v. the installation of a bank of three 625-kv.a., 11,000-2300-v. transformers, delta connected, was necessary to allow such parallel operation.

For light and power service—except in the case of some few instances where 2300-v. motors are employed—the voltage is reduced to 110 and 440 v. respectively by local transformers.

The maximum electric load is about 2300 kw.

Motor sizes range from 5 to 300 hp.

Revival of Industrial Activity in Europe

Its Relation to the Development of the Available Sources of Power Supply. By L. W. Alwyn-Schmidt

REVIVAL of the world's economic activities following the war is closely connected everywhere with a reform of power generation and distribution. Engineers and economists having realized that the pre-war system of power generation was wasteful and proved unhandy during an emergency, have set themselves to correct the mistakes of former years by directing into more suitable channels all activities connected with the production and consumption of power. In doing so, it has been shown that pre-war power generation had grown upon an industrial system faulty in itself and that the industrial methods employed in nearly all progressive industrial nations were antiquated, having sprung from practices introduced when power engineering was still in its earliest stages. One must not forget that power production and power engineering as we understand it today is comparatively young and that there have passed hardly 100 yr. since steam power has been employed in its modern meaning. The principle involved in the present reforms is that of higher centralization of the generation in order to make it more economical and so cheapen the means of distributing power to the points of consumption. This must be done in a manner least disturbing to the present state of the power industry and in such a way as to permit the most exhaustive use of that equipment which is in existence. Steam power generated by coal and gas will find employment in this new scheme of power generation as much as centralized electrical power generation. Also the possibility of the sudden discovery of new power sources like that offered during the last century by the discovery of electrical energy cannot be left entirely out of reckoning.

The two steps taken first in each country have been: an investigation into the demand for power supply and its probable increase during the next years; and further, a charting of all the available sources of power that have not been tapped so far. With the knowledge obtained by these two lines of research, it will then be comparatively easy to map out a course of procedure that will govern the power industry and its development for whole regions, countries or even continents, as the case may be.

A typical example of organized activity for the reform of power generation and distribution in this respect is England. The English government has a way of procedure in the development of large national questions by way of governmental committees which is both easy to apply and effective in use. The appointment of an investigating committee can be made by any of the governmental boards in control of the public business and the work of the committee not only shows a way to effect the purposes of its investigation but it also prepares the mind of the public most thoroughly for any coming change by keeping the nation informed about its activities. The water power investigation committee appointed by the British Board of Trade during 1918 has not been any exception from this rule. It has examined and reported upon the water power sources of England and in doing so has laid the foundation for a far-reaching policy of national development of water powers that there is hardly a voice raised today in England against its execution. So far, only an interim report is available. This shows that the water power resources of England are fairly plentiful and that Scotland alone possesses nine excellent sites giving a power development of 183,000 hp.

English Water Powers Will Be Developed

These water powers, if harnessed, are able to produce 1,200,000,000 Board of Trade units of electrical power which is approximately one-quarter of all steam-power-generated electrical energy produced at the present time in England. Nearly 2,000,000 tons of coal would be saved by the development of the Scottish water power alone. There is more power available in Scotland than is required for feeding the industries of Scotland employing electrical power at the present time, permitting for an enormous expansion in the use of electricity in such cities as Glasgow, Edinburgh, Aberdeen, Dundee, and others. The cost of completing these nine Scottish schemes is estimated to be $35,000,000 approximately, and Scotland would have its electrical power at this rate very cheaply indeed.

The investigation has quickly created an interest in the development of one of the discussed sites in Scotland and the city of Dundee and other municipalities in the neighborhood are said to have taken into consideration the construction of a large power station, if necessary with government aid.

While opinion in England hardly differs about the water power possibilities of Scotland there are considerable differences about the value of the water power resources of England proper and Wales. Experts heard before the investigation committee have expressed varying opinions. The committee itself seems to think that there are sufficient water powers in both countries to make worthwhile their close investigation and later development. It seems that national sentiment as represented by the large landholders in southern England is somewhat averse to a wholesale development of water powers in England. But England, having started upon a period of rejuvenation, will hardly let vested rights interfere with its new plans of economic development and progress will be rapid now after the first step has been taken.

The general recommendations of the committee are of interest to American readers because they lay down a fundamental policy which should govern similar investigations in our own country. The committee proposes the formation of a permanent council for the following purposes:

"The compilation of proper records of the water resources and present and future water requirements of the country, and the collection of information on these subjects through existing departments and other agencies as well as by its own hydrometric staff.

"The allocation of these water resources in the general interest of the community and powers to adjust

existing allocations of water where hardship or anomalies are clearly shown to exist.

"The adjustment of conflicting interests in connection with the use of water for particular purposes.

"To assist the government departments concerned with the use and control of water, the various local authorities and water supply undertakings, and to afford assistance to parliamentary committees before whom water or water power bills may be heard.

"To confer with a statutory interdepartmental water committee with the view of avoiding duplication of work and delay in procedure.

"To group the watersheds of the country into suitable areas, and where desirable to arrange for the setting up of watershed boards.

"To consider the development of rivers as a whole from source to mouth from the point of view of all water interests, and when necessary to initiate legislation for securing such development.

"To bring forward proposals for improving the law relating to surface and underground waters and their utilization.

"To appoint as necessary an advisory committee of representatives of water undertakings and scientific institutions, consulting engineers, or other specially qualified persons for the purpose of giving advice or reporting on any matters which come within the purview of the commissioners."

Financial England, having taken the hint, has come forward freely with capital for electrical power extension and more than $25,000,000 were subscribed for new undertakings and the expansion of existing ones during the first 9 mo. of the year 1920 alone, which is nearly double the amount spent for the same purpose during the first 9 mo. of the preceding year.

That the power problem of England is one of considerable urgency is shown by the experience of such cities as Bradford and others during the recent coal strike, when all reserves were practically exhausted. Most industrial enterprises were running on current deliveries and there are instances where large factories were compelled to close down or run on short time until new coal had arrived. It is estimated that the woolen industry around Bradford requires 3,500,000 tons of coal alone every year. In Bradford electrical consumption was doubled during the war and the erection of large power stations under national control finds wholehearted support all through industrial England.

Tapping New Power Sources

As to the discovery of new sources of power outside those already employed, researches are now made in England with a view to increase the use of alcohol for power production. This question has been discussed already frequently in the technical press of all countries without, however, finding any satisfying answer. In India, researches are now under way to determine the practicability of producing power alcohol from rice, straw and other cheap raw materials. At the same time experiments are made in England to develop an alcohol motor that can give employment to the fuel when produced in a sufficient quantity. One of the obstacles in the way of a general employment of alcohol for industrial purposes is still the fact that it may also find use as a beverage. In view of present day discussions of the same subject in our own United States, it is interesting to see the standards established by the British Empire Motor Fuels Committee as to what constitutes possible denaturant. These are: Deterrent in taste and smell, non-poisonous, must not be removable at a commercial cost, must be readily detectable in small quantities, must be readily mixable with the spirit and must be inexpensive.

Situation on the European Continent

Little news is at hand about the progress of power development in Germany. It seems that the general disorganized state of all economic life is the principal obstacle in the way of power development of any nature in that country at the present time. A law regulating power distribution is under discussion and most likely will take some concrete form together with the expected regulation of coal mining which it is proposed to put under national control. Germany is the country where public ownership of public utilities had made most progress during the period before the war. It is, therefore, interesting to see that public opinion as expressed by commercial and industrial interests seems to be much averse to a further extension of public ownership in the case of the coal mines and other power utilities. It is said that public ownership as opposed to private ownership under public control has not brought the desired benefits to the nation. Strikes have been just as frequent in the publicly owned undertakings and the lack of incentive among the officials directing these enterprises is not conducive to improvement in service and production. Nevertheless the Germans seem to be willing to make the experiment as there is apparently no other means of securing the future co-operation of the coal miners.

In France the large hydroelectric power plant of the Societe Hydro-Electric of Lyons was completed recently. The plant has 20,000 hp. and is situated at Seyssel, Haute Savoie. It has at the present time four turbines developing 5500 hp. each, but a fifth one will be added in short time, bringing the total capacity to 27,000 hp. This plant is interesting in so far as it is owned in common by a gas and an electric company which in this manner have brought about a co-operation of interests in the district that is served by the new plant. There are a great number of new hydroelectric plants under construction in the south of France which will be excellently supplied with electrical energy in the course of the next few years.

The progress made in France and the need of giving the country a better supply of power have stimulated interest also in Spain and during the last year various new projects have been mentioned in the press. American capital is employed in Spanish electrical development and it is not unlikely that the new installations will be of American origin. Spain has a variety of excellent hydroelectrical power sites, but is still employing coal as a principal power generator in the case of private power installations. A good example of a large private installation is that found in the shipyards of Cadiz, where electricity, steam, hydraulic and pneumatic power combine to make an almost perfect power supply. The power house, which is nearly 700 yd. long.

is equipped with boilers and two steam engines of the compound system which are coupled directly with the dynamos. With the aid of this station, most of the power is generated for operating the large machinery. Additional power is bought from the local power station.

Portugal also has taken up the question of power development upon a national basis. This country being a part of the Pyrenean Peninsula, and a minor part only, has developed a power problem of its own. It happens that the river most suitable for power development in Portugal has its headwaters on Spanish territory. Spanish farmers would find it easy to draw a sufficient quantity of water from this river for irrigation purposes to destroy the power capacity of the river lower down. Portugal, therefore, has made approaches to Spain to arrange some sort of an agreement giving her security in the possession of her water powers. Most of the rivers that might be used by Portugal for water power development will require dam construction. A committee has been formed to study the situation and to make proposals for hastening the development of such sites that promise good results.

Denmark, in taking over a small slice of the former Germany, also has taken possession of a few smaller electrical power stations, although the large stations of the territory under dispute have remained upon German soil. As it is, these newly acquired stations are not all a blessing to Denmark and only increase the complexity of the power situation of the little kingdom. Denmark has built up in recent years a respectable industry which, in conjunction with its intense farming, gives the country a considerable prosperity; but, unfortunately for Denmark, there is no good coal to be found inside its boundaries, which makes manufacturing always a precarious matter as conditions are today in Europe. Formerly most cheap coal was imported from Germany, but German coal is rare today all over Europe, and Denmark, during the last year, could purchase only ¼ of the usual supply. The price of German coal being excessively high, English coal was resorted to for a while with good results until the English coal mining strike ended the connection, which has not reached again its former importance for Denmark. Hope had been expressed that America would be able to take care of the Danish coal exports; but the lack of enterprise of the American coal exporters, which is severely criticized all over Europe, made American help a forlorn hope, so that nothing is left at the present time for Denmark than to resort again to its peat coal resources and, if possible, to reach some agreement with Sweden or Norway for the supply of electrical power from hydroelectric resources in these two countries.

Financial Difficulties Hinder Power Development

An interesting sidelight upon conditions in Europe is given by the difficulties of the Swiss Electro Bank, generally known as the Bank for Electrical Undertakings, an enterprise which has played an enormous role in the development of electrical enterprise all over Europe and had been considered of inexhaustible resources. The organization is a sort of a trust company holding shares in many electrical enterprises. It assisted in financing electrical enterprise all over Europe, in Germany, Russia, Italy, Austria, Spain, France, in fact wherever its resources could be employed to advantage. Having an excellent staff of electrical experts and being supported by large banking houses all over the world, the institution enjoyed a great prosperity. But the war has killed it by upsetting the international exchanges. An income derived from roubles, marks, and other similarly devalueized currency could not provide the support of a business conducted in Switzerland, where francs had to be paid out. The unsecured loss by decline in exchange runs into 49,000,000 francs. A reorganization of the institution is contemplated in view of the fact that the properties in which it is interested are in most cases sound in principle. The loss is only a paper loss and the rectification of the exchanges, no doubt, will bring back the bank to its former prosperity. The Swiss Electro Bank shares this experience with other similar institutions and private financial undertakings in Europe who had invested in foreign industrial firms and are now finding themselves the losers.

The financial situation caused in this manner in Europe interferes a great deal with the financing of power projects and is one of the reasons why progress has been comparatively slow during the last few months.

Safety First

By Chas. Knapp

THE telephone rang; chief answered the call.
"To hell, you say, is that all?
Send 'em down, I'll show 'em around—
Nothing but safety first to be found!"

Safety inspectors, hm, who cares?
Won't catch me this time, unawares;
Learned my lesson months ago—
Bawled out proper, I'll say so!"

Found the gov'nor on old four blocked,
Blocked at low pressure 'cause she stopped;
Safety stop valve wasn't set—
Queer how some folks will forget!"

Inspector went down to the boiler room,
Safety valve popped with a mighty boom;
He gazed at the pressure gage, 'Damn!' he swore,
'Been set up again, five pounds more!' "

I had it set up, for the 'Super' said,
'Need more steam to run full head!'
I had it set up, but, never again,
Will the pressure exceed one-hundred and ten!"

I took the blame, but resolved right then,
I'd never be caught that way again;
Being caught once will show why the way
Of 'Preparedness' is best most any day!"

And prepared I am; when inspectors come,
They'll find there's nothing I've left undone;
I'll not be bawled out, nor will I be cursed—
I'm a staunch believer in SAFETY FIRST!"

Improving Operation in an Old Plant

INSTALLATION OF INSTRUMENTS AND MODERN EQUIPMENT EFFECTS A DECIDED SAVING IN COAL BILL

PROBABLY no other single factor in the field of steam engineering has afforded greater impetus to the installation of improved and modern equipment in old power plants than the increased cost of fuel. This, of course, was only natural since fuel in a power plant is an absolute necessity and must be had at any cost; hence, the only method of decreasing the size of the fuel bill was to reduce the operating costs and the amount of fuel consumed for a definite amount of power developed. Without doubt, this is most effectively accomplished by the installation of suitable instruments and recording apparatus, followed by a correct interpretation of their records and the application of proper remedies for unsatisfactory conditions noted.

FIG. 1. VIEW IN BOILER ROOM

This was the procedure pursued at the plant of the American Diamalt Co. at Cincinnati, O., where the installation of boiler room instruments and other equipment has indirectly resulted in a decided reduction in the operating costs. It must not be inferred, however, that a plant equipped with a conspicuous array of meters, recorders, and other instruments is operating economically. The mere fact that a number of instruments are installed means nothing unless the records furnished by such instruments are intelligently interpreted and used as a basis for improving operation. Such records tell a story. It is the duty of the chief engineer to translate this story into terms of operating procedure and finally into dollars and cents saved.

The instruments recently installed at the plant referred to above, in themselves would not be of great assistance as a factor in reducing costs, if it were not for the fact that the chief engineer spends a large portion of his time studying their records and directing his operating force accordingly. Since these instruments together with other new apparatus were added to the existing equipment, they have indirectly reduced the amount of coal consumed over 20 per cent and that with coal of a lower thermal value than that which was formerly used.

The old plant consisted of five hand fired, water tube boilers totaling 1675 rated horsepower, which furnished steam for power and process work in the manufacture of Diamalt. About 92 per cent of the steam generated is used in the factory for boiling and condensing purposes, all steam boiling being done under vacuum pans. The remaining 8 per cent is used for the generation of electricity and in operating pumps and air compressors.

Within the past two years, mechanical stokers of the underfeed type have been fitted to all the boilers, automatic apparatus for the control of combustion has been added and a complete line of boiler meters, recording thermometers, and CO_2 recorders has been installed. A novel method of storing and heating the large amounts of condensate is of particular interest because of the unusual operating conditions this plant must contend with. Recording instruments are also provided for furnishing records in regard to the use of exhaust steam and for determining the frequency of the blowing down of the boilers.

ODD USE FOR RECORDING THERMOMETERS

THE TYPE of boiler meter employed is of a standard design, simultaneously recording steam flow, draft, and flue gas temperature and its operation needs no description. The method of obtaining a record regarding the use of exhaust steam for factory purposes, however, is novel and a description may be of interest.

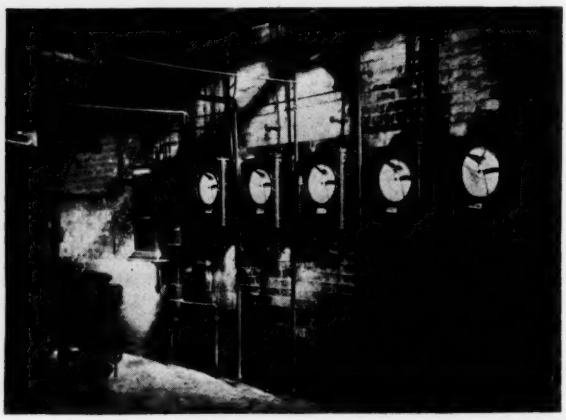

FIG. 2. NEW METER INSTALLATION

In addition to consuming a great amount of live steam, the factory finds use for the exhaust steam from the engine room equipment at intervals. To record the number of hours per day that exhaust steam is used in this manner, an arrangement such as is shown in Fig. 3 is provided. A small pipe is tapped into the atmospheric exhaust line above the atmospheric relief valve. The end of this pipe is left open and is arranged to discharge into the sewer as shown in the sketch. The bulb of the recording thermometer is placed directly below the outlet of the small pipe in such a manner that any steam or hot water issuing from the pipe will cause the thermometer to register a higher temperature. With this arrangement it is evident that if the factory is using

exhaust steam, the atmospheric relief valve will remain closed and a low temperature will be recorded by the thermometer. Should the factory shut down on the use

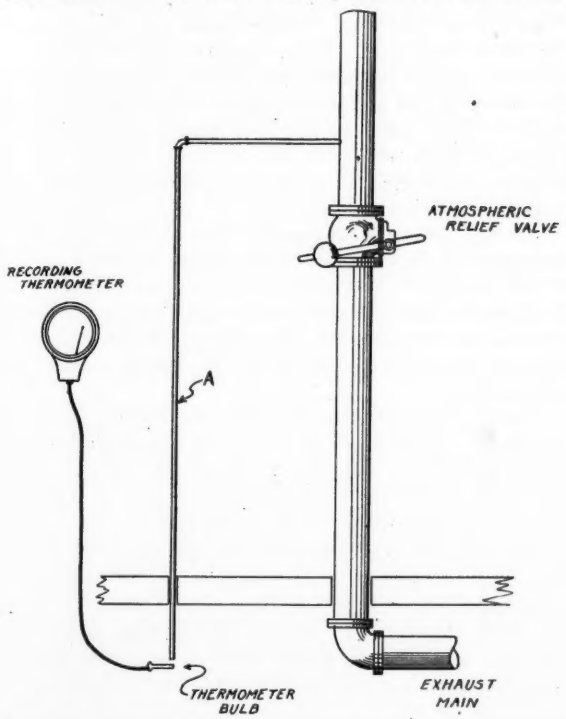

FIG. 3. USE OF EXHAUST STEAM RECORDED BY THERMOMETER

of exhaust steam, however, the amount of back pressure in the exhaust line will increase and the atmospheric relief valve will open. Steam or condensate will then find its way down the pipe A to the bulb of the thermometer causing it to record a high temperature and supplying evidence to the fact that exhaust steam is not being used. A record furnished by this thermometer is shown in Fig. 4.

Recording Boiler Blowoff Procedure

An arrangement similar to the above is employed for determining the frequency with which the boilers are blown down by the various watches. In this case the thermometer bulb is placed at the end of the main blowoff line. Each time a boiler is blown down, the recording thermometer connected to this bulb will register a rise in temperature and an accurate record of the number of boilers blown down by each watch is thus secured. A chart of this kind is shown in Fig. 5. The tall peaks indicate the blowing down of a boiler, while the small peaks indicate the operation of the try cocks which are also connected to the blowoff line. It may be noticed from this chart, that where two boilers are blown down in rapid succession, the second peak is higher than the first. This is due to the accumulative effect of the temperature in the blowoff line; the thermometer bulb being so located that it requires an appreciable length of time to heat up. In this manner an accurate check is obtained on the reports of the operating force.

Draft Control

Draft on the boilers is controlled by a system of balanced draft, i. e., the individual dampers are regulated by the pressure of the gases in the furnace. This is accomplished by a novel regulator, designed and patented by Mr. Craig, the chief engineer at this plant, which is extremely simple and self-contained. It has only three moving parts, has no stuffing-boxes under high pressures, and its sensitiveness can be controlled to any desired degree.

This device can be seen as installed in the photograph, Fig. 1, at A. It consists essentially of a metal bell floating in water, the inside of which is in communication with the interior of the furnace. Variations in pressure of the furnace gases thus vary the pressure inside

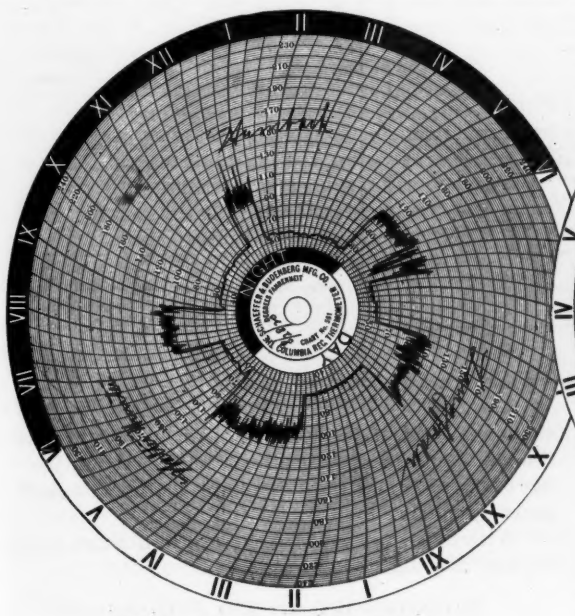

FIG. 4. EXHAUST STEAM CHART

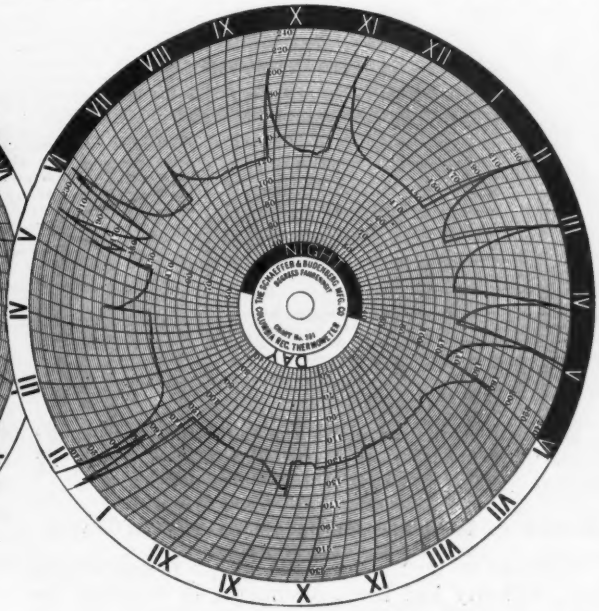

FIG. 5. BOILER BLOWOFF CHART

the bell and cause it to increase or decrease in buoyancy as the case may be. In this manner, the variation in pressure controls the motion of a pilot valve which in turn controls the operation of a motor cylinder. The bell is counterweighted and the amount of draft desired is regulated by varying the weight of this counterweight.

The extreme simplicity of the device together with its ruggedness and absence of delicate mechanism ren-

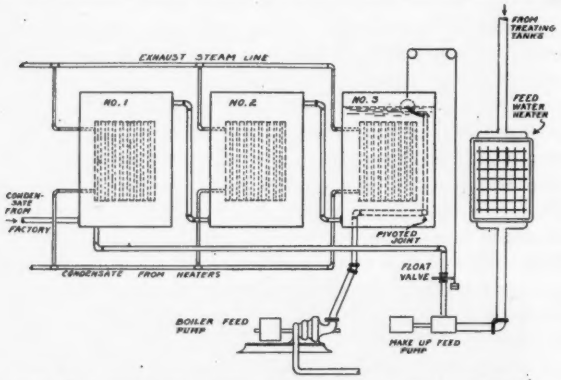

FIG. 6. STORAGE TANK AND HEATER ARRANGEMENT

ders it of particular value for use in the fireroom. This regulator, it is claimed, will hold the draft constant to within 0.01 in., and it can be operated from any ordinary city water supply line. In fact, it will operate with perfect satisfaction on water pressures as low as 4 lb.

It was, therefore, decided to erect three large storage tanks of 10,000 gal. capacity each which would be able to handle the maximum amount of condensate that could come over at one time. These tanks are located above the boiler room and are arranged as shown in Fig. 6. To make up for the water lost in the various processes, the storage tanks are also supplied from four 18,000-gal. water treating tanks on the roof. Such make-up water passes through the feed water heater shown and is pumped into storage tank No. 1, which also receives condensate from the factory.

As the tanks are arranged in series, the water passes successively through the three tanks, entering at the bottom and leaving at the top in each case. Each tank, furthermore, is fitted with an exhaust steam heater, constructed on the principle of a fire-tube boiler; the water passing through the tubes while the exhaust steam flows around them.

Boiler feed is taken from the last tank as shown in the sketch; a float secured to a pivoted suction pipe making it possible to take suction near the surface of the water at all times. This is necessary due to the large amount of sediment present in the tank.

The float is also connected through a system of pulleys to the make-up feed pump so as to control the amount of water supplied from the treating tanks on the roof. If the water level in the storage tanks falls, the float opens the discharge valve of the pump, thereby increasing the quantity of make-up water delivered. On

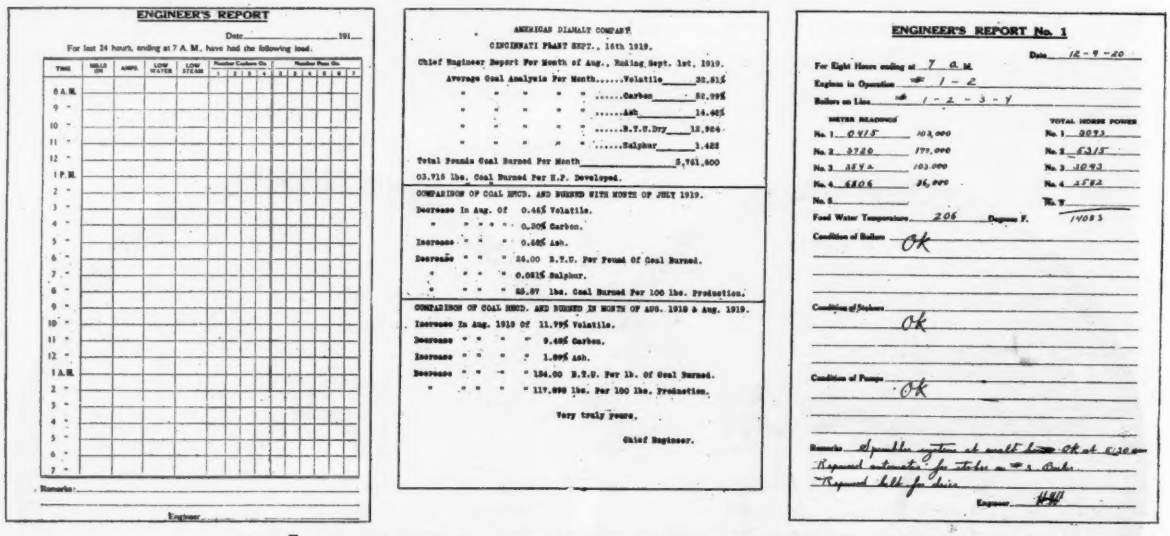

FIG. 7. TYPICAL REPORTS USED AT THE AMERICAN DIAMALT CO. PLANT

As installed at this plant, the regulator controls the damper only, the forced draft fan being controlled by the boiler steam pressure.

Method of Handling Condensate and Feed Water

Previous to the time of installing the present equipment, difficulty had been encountered in handling the large amount of condensate which comes over at intervals. All condensate is used as feed water and it was found that practically no feed water heater of sufficient size could be procured which would heat the large slugs of condensate.

the other hand, if the speed of the boiler feed pump decreases, due to a light load, the water level in the storage tank rises and the float stops the operation of the make-up pump.

With this equipment, an average feed water temperature of 208 deg. F. is secured.

Engineer's Reports and Fuel Analysis

The installation of the equipment described in the foregoing together with the excellent system of records kept has resulted in effecting a marked saving in the cost of manufacturing the product.

Each watch engineer as well as repair man is required to turn in daily report sheets, to the chief engineer. These daily report sheets together with the instrument charts and the weekly report on the coal analysis, enable the chief engineer to submit monthly and weekly reports to the management which are exceedingly thorough. At the end of each month, a comparative report is made between the preceding month and also the same month of the previous year. Typical report sheets are shown in Fig. 7.

Coal analyses are made at the plant by an experienced chemist. A sample of each analysis is kept in a sealed container for at least six months after analysis, so as to eliminate any controversy between the coal company and the management in regard to the quality of the coal contracted for. A similar procedure is followed in the purchase of lubricating oil, a sample being kept on hand so that if at any time during the year the oil delivered falls below contract specifications, there can be no doubt as to the accuracy of the original analysis.

Future Power Development*

SUGGESTIONS FOR FURTHERING CO-ORDINATION AND CO-OPERATION OF EXISTING SOURCES OF SUPPLY AND THE CONSERVATION OF OUR NATURAL FUEL RESOURCES. BY J. E. JACKSON

THE SHORTAGE of central station power is serious by reason of the fact that it interferes materially with the natural productive growth of our country and with the prosperity of its several communities. Another even more serious element relating to such power shortage is the fact that it continues the use of a number of isolated steam and electrical plants, which are consuming from two to four or more times the amount of fuel which would be required were their power supplied from the central power systems, such as are gradually being developed throughout the country. The waste of power through the use of such isolated plants and also by the railways, on account of the heavy fuel consumption of the steam locomotive and avoidable coal haulage, not only adds an unnecessary burden in costs of production, but, in addition, causes a waste and excessive dissipation of the fuel resources of our country.

Moreover, the lack of sufficiently adequate central power systems makes impossible the economic utilization of many water powers which would become available if they could pump their power in the form of electrical energy into great electrical distribution systems. Many water sheds, which can not be economically utilized otherwise, can be used in connection with large water storages for the purpose of taking off seasonal or annual load peaks, while others of a widely different character, known as flow of river or "fugitive" powers, when connected to a system which supplies a relatively great power absorbing demand, can be so operated that the greater bulk of the annual, available power of the streams is absorbed profitably and usefully.

The following are among the most important activities to be undertaken in connection with the power situation as it faces the country today:

1. To design the construction and direct the operation of central power systems so as to make possible the highest practical economy and largest conservation of natural resources and labor; and also to provide a fully adequate supply of power for all purposes, not only in the great centers of population, but throughout the country.

2. To arrange by interconnection transmission systems and otherwise, so that the maximum amount of water power may be developed, though the amount of water power utilized can and will greatly increase with the rapidly growing power demands. It is believed that much wisdom will be required to utilize such power in many important industrial sections of the country where water power is scarce, to a greater percentage of the total power than now exists. Many watersheds having reasonably constant flow, but not accessible for connection normally with central power systems, can possibly become of early value for developing the electrochemical processes of the country and incidentally, to some extent, in reducing the consumption of fuel.

3. To place steam plants, as far as possible, close to coal mines or on waterways in order that energy may be transmitted as much as possible in the form of electric power rather than in the form of coal, with the probable reductions of freight charges and relief to railroad traffic.

4. To supply practically all industries with power from central power systems, which would result not only in an enormous coal saving, but also in a large saving in man power, maintenance supplies, and in transportation.

5. To electrify extensively the railways with the consequent great reduction in fuel consumption and relief from carrying a large dead weight of coal freight for their own purposes, and also to make available the largely increased duty of their trackage and equipment that is possible by electrification.

6. To make the central stations not only adequate for all of the foregoing purposes and the expected future growth, but fully reliable. It is a long cry since the day when the popular belief was that any old "clothes line" would do to transmit electricity, but even yet it is not unseldom that industrialists hesitate to depend wholly upon central station power. J. W. Lieb sets forth emphatically the need of "absolute continuity of service" in the discussion of electric supply at the American Institute of Electrical Engineers' meeting in February.

7. To work out programs which will enable the financing to be handled with facility. By the census, there were three billions of dollars invested in 1917 in central stations, not including electric railways. About double that is needed now or as soon as the equipment can be produced, say in 1922 or soon thereafter, and four times the 1917 capital will be required well before 1930 if reasonable progress is made. The 1917 investment was at the rate of about $333 per kilowatt installed,

* From a paper read before the A. S. M. E.

including secondary distribution. To obtain the great sums of money necessary meant, primarily, that the investments must be profitable and stable.

8. To conserve a larger proportion of the valuable chemical constituents in the coal, such products are now recovered from only a small percentage of the total coal mined. Closely related with the coal problem is the conservation of our oil and natural gas supplies. This problem is acute, for our oil and natural gas are showing signs of exhaustion, and while under present rates of consumption our coal may last a few thousand years, if the present increase in the rate of demand continues, it will be exhausted in a very limited time.

The large sums of money indicated as necessary during the next few years for power development will in a large measure be spent even though no concerted effort be made to solve the power problem by a fully co-ordinated plan; but without concerted action, there would be no possibility of such excellent returns, either in dividends or conservation of natural resources and labor. In 1915, had we been advanced to a point of highly efficient central electrification of all power absorbers, with reasonable use of water power, the saving in fuel alone would have amounted to several hundred millions of dollars per year, with a probable total saving of from two to three times as much if labor and all economies were included.

The following suggestions with regard to power districts and unification are intended to indicate the lines of a concerted policy of unification which would encourage these savings and at the same time promote the power business largely along the natural lines in which it is now developing.

Natural Power Districts

The trend of power development during the past few years, and the present tendency, is the enlargement and unification of the power systems in large "natural power districts." The boundaries of a natural power district are determinable or limited by the considerations that each region should be sufficiently large and the load of a character to enable it to sustain such size and character of generating plants and so use them as to give high economy, and at the same time the territory be sufficiently compact to enable the exchange of power between the several parts to be carried on conveniently and effectively. Due regard must also be paid to the location and character of the natural power resources. A unified central power system supplying the power requirements of such a district makes possible highly economical service by reason of its ability to reduce to a minimum the aggregate amount of fuel used in the power plants—by raising the use factors of the most economical plants, and lowering others—to take advantage of load diversities in the several parts of the natural power district, to maintain a minimum of reserve equipment, to place necessary new plants at the points most effective from the standpoint of natural resources and the load, to utilize water powers more fully, and to permit a higher degree of reliability.

The selection of power rights for the best use of coal mines, condensing water, water power, etc., has already become difficult with the present large stations and power demands, and with the great expected growth of these demands this problem will become more difficult. Unified action in a power district is of much value in this regard.

Those in charge of operations in a district must design the unified system in a manner which will carry approximately the same efficiency of production and delivery of power to all users of power over the whole district, as is now attained in the big centers of power supply, if reasonably satisfactory conservation of our resources and the best welfare of our country and the power companies is to be obtained.

It is evident that such objects require full standardization of voltages, frequencies, systems, etc., throughout the district, or, better, the whole country. Such standardization mostly exists in the United States, but it has not reached perfection. An example of this is the larger horsepower in equipment using 25 cycles in iron and steel mills where the central stations are generating at 60 cycles.

At the present time, the growth and unification of power districts is proceeding steadily, as may be noted by the situation in the New England States, the tying together of various companies and successful co-operation in Western Pennsylvania and Eastern Ohio, the getting together of a number of power companies in a group of the Southern States, in the unified control of the central station systems of the Pacific Coast, etc. This kind of co-operative development was given a distinct and important impetus forward, during the war, by the Power Division of the War Industries Board, headed by Frederick Darlington, which was faced with the problem of relieving a shortage of both power and fuel, and the development of additional power to meet the rapidly growing demands caused by war activities. Mr. Darlington, after having examined the subject, concluded that the wisest procedure was to take advantage of and promote the natural tendency toward unification and co-operation of power interests in natural power districts, and with this object in view, dealt with several sections of the country as distinct units.

This decision, combined with the co-operative spirit of the people in carrying on the war, rapidly crystallized the policy of developing unified power systems within natural power districts. Undoubtedly, such a general policy as this can be continued and developed not only to advantage, but readily, since many of our prominent power and financial men have already become accustomed to it.

Experience during the war and various results found in peace times are sufficient to lead to the conclusion that both investment and operating costs will usually be so reduced by unification in natural power districts as to make this kind of power supply attractive from the financial point of view. In the district examined recently by the writer and others, already referred to, there were possibilities of saving material amounts through the requirement of less reserves and more effective use of equipment, and by 1926 it was estimated that the total cost of generation and trunk delivery of power would be reduced from about 9¾ to 3½ mills as compared with independent operation. This represents several millions of dollars and a substantial increase in earnings. There are other districts where much more marked savings are indicated.

Equipment Costs

By Hubert E. Collins

AT THE time of this writing (January, 1921), we feel that we have reached the peak in the cost of new power plant equipment. Prices have changed so rapidly in the last 5 yr. that most of us gave up trying to estimate values and in fact could not do so.

It is interesting to take advantage of a period where the prices remain stationary long enough to note them.

The following data is offered for the use of those contemplating installation in the near future and for the owners who wish to know present-day valuations.

It is hardly probable that valuations will go up further than here quoted and at the same time it is not likely they will fall much for some time to come. The reason for this is that labor is the largest part of the costs both in cost per hour and reduced unit production for the labor.

Whereas, up to 6 yr. ago, we could estimate piping jobs on a 50/50 basis for labor and material we now know that it is nearer 85/15 with labor the higher part and still the unknown quantity for the reason that the return to the old standard of production for given time is hard to gage.

Therefore it is likely that the valuations here given with the explanations will be of service to many at this time.

With this in mind, the following tables of valuations with explanations are offered:

Equipment Costs in Plants 500 to 1000 kw.

1. Boilers (H.r.t. and water tube)	$44	per hp.
2. Piping (of boilers)	6	" "
3. Piping (Boilers to engine)	6	" "
4. Piping (Exhaust to atmosphere)	3	" "
5. Piping (Feed pump)	2	" "
6. Breeching	4	" "
7. Stack (Radial brick or concrete)	5	" "
8. Reciprocating eng-generator units	53	" "
9. Turbine-generator units	47	" "
10. Condensers	8	" "
11. Feed Pumps (delivered)	400	each

1. The costs here include boilers purchased, delivered and set up in place with the brick work.

2. This includes all fittings and valves with pipe and the necessary labor to install. It does not include pipe covering. It is the piping necessary to connect the boilers together and includes all necessary headers from which steam will be taken for engines or other steam consuming devices.

3. This includes all necessary valves, fittings and pipe with labor from the boiler headers to the engines in an average plant. If exceptionally long runs are made from the boiler headers these figures must be supplemented. Covering is not included.

4. This includes all necessary valves, fittings and pipe with labor from the engines to the atmosphere where the runs take the exhaust to the roof of a power house just outside the engine room. It also covers cross-connection with heating systems in the power house. It does not include covering.

5. This includes all necessary valves, fittings and pipe with labor for steam and water connection from boilers to pump. It does not include covering.

6. This includes material and labor to place breeching ready for service to connect boilers with stack outside boiler room. It does not include covering.

7. This includes price of stack, foundation, excavation for foundations, backfilling. It is the completed job ready for service. It is based on the capacity of the stack as given in tables of stack capacity for given height and diameter. Up to a year ago the concrete stacks were 30 per cent cheaper than radial brick but are now about equal. A stack built by other than firms making a business of it and of common brick will cost more than here given.

8. This price includes the latest "style" of unaflow type engine. The price is higher than the turbine type because of more copper required in the generator. It includes erection.

9. This includes erection in place ready for connection to steam, exhaust and electrical connection. It includes the exciter units necessary for alternating current.

10. This includes the condenser set in place with the necessary auxiliaries ready for connection.

These prices include everything specified except: Foundations for engines and all auxiliaries of engine and boiler room; foundation under boiler settings together with necessary excavation; piping and covering for the condensers aside from the exhaust line; engine room switchboards with all connections from generator to bus bar; auxiliary apparatus as air compressors, blowers, ash removal or coal handling equipment, refrigerating or other apparatus than named. For this reason the writer estimates that the average plant is worth from $210 to $240 per horsepower aside from the buildings.

Building costs vary greatly but in one instance last year we put up an entirely new boiler house separate from other buildings to house 870 b.hp. which cost $38,700 complete, or $44.50 per boiler horsepower.

Coal Storage and Handling Equipment

This varies greatly and will be cheaper for the large installations in unit price. For small installations we have the following:

One concern invested in an equipment covering a steel storage bin for a 20-day summer coal supply and a 9-day winter supply. They also included unloading and elevating machinery with delivery from the bin or bunker to the fireroom floor with an industrial railway for coal car in boiler room. This made a complete equipment for this place. This equipment, including the owner's costs of preparing for the installation, came to approximately $18.50 per boiler horsepower. This valuation will cover plants of the smaller size.

Ash Removal Equipment

Three installations during the last year for this sized plant were of the "steam ejector" type and cost $2.60 per boiler horsepower.

These equipments in each case were minimum size and would take care of much larger plants at a consequent lower cost per boiler horsepower. It would be safe to estimate this equipment for larger plants at $2.25 per boiler horsepower.

The foregoing valuation includes all necessary equipment for ash removal, ash storage, and cost of installation.

Large-Unit Installations

Large power plants call for lower unit costs. The prices of water-tube boilers designed for working pressures of 170 lb. per sq. in. gage ranged from $32.40 per boiler horsepower for 105-hp. units to $19.75 per boiler horsepower for 1016-hp. units. Some boilers of the curved-tube type were from 30 to 40 per cent higher.

These prices include brick work for settings but do not include the foundation preparation.

Open-Type Feed-Water Heaters

150 b.hp. under worst conditions.....$ 400 each
5500 b.hp. " " " ..... 1500 "

These are set up for connection and do not include foundations.

Superheaters

For water-tube boilers, 170 lb. pressure, 200 b.hp. and over.

100 deg. F. superheat $5 per b.hp.
150 " " " 6 " "

Heating Equipment

For factories, including piping, radiation, valves and return pumps, cost of radiation is $1.75 per sq. ft. This is for a gravity system. A vacuum system with patents on the system and radiator valves will cost $2 and over per sq. ft. of radiation, depending on the system.

So-called "vapor systems" for factory and house call for more radiation per cubic foot of space and will run up to $2.50 per sq. ft. radiation for house installations.

Lighting Equipment

Modern factory illumination calls for more expensive reflector equipment in the shape of glass globes and reflectors designed to give the best light without glare and this part of the equipment gives the greatest unit cost.

One installation last year which included all wire from the switchboard in the engine room to the farthest point reached for light, conduit, panel boxes, outlet fixtures, and all reflectors, including the glassware in globes of patented make, came to $25.25 per outlet.

Motor Equipment

The following prices for motors are for alternating current, 2- or 3-phase, 60-cycle, 220- or 440-v., complete with pulley, base, and starter, delivered ready for installation.

Price per Electrical Horsepower

Speed Hp.	1	2	3	5	7½	10	15	20	25	30	40
1800	95.00	57.50	41.66	29.00	32.70	28.50	....	....	....	....	....
1200	105.00	62.50	48.33	34.00	38.00	33.00	24.00	20.00	19.60	18.65	....
900	.....	....	....	47.00	43.30	34.50	26.60	24.50	22.00	21.00	18.75
600	.....	....	....	....	....	....	....	....	....	27.70	24.75

Burning Lignite*

Methods Employed and Results Obtained. By T. A. Marsh

Among the lowest grades of fuels with which combustion engineers must work are the lignites and high-moisture fuels, many of which contain more than 40 per cent of moisture and less than 6000 B.t.u. when mined. From such fuel, it is evident that even after obtaining satisfactory combustion the net heat delivered to the boiler is small, owing to the low initial heating value and the loss from evaporation of the moisture in the coal. The problem has presented such difficulties that there is a prevalent opinion that lignites cannot be successfully burned. It is the purpose of this article to describe methods of burning these fuels and results obtained in their combustion.

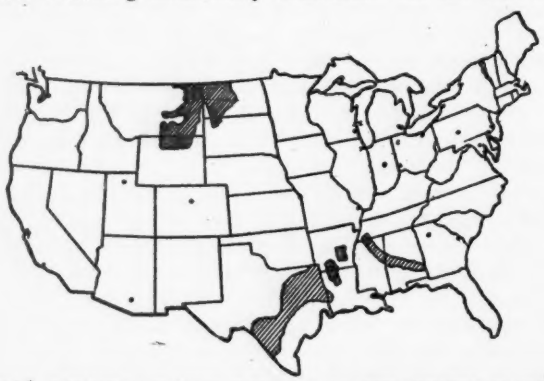

FIG. 1. LIGNITE DEPOSITS EXISTING IN THE UNITED STATES

Lignites contain on the average from 20 to 40 per cent of moisture when mined. These fuels have a spongy structure and woody fiber. They slack on the surface within a few hours when exposed, the action being similar to that of lime when slacked. The drying process, unfortunately, does not penetrate deeply into the pile, but is a surface action. On account of the high percentage of moisture and the slacking property of lignite, it cannot be successfully transported far from the field where it is mined. This has, of course, limited the utilization of this fuel.

On a plain chain grate, the volatile gases burn off rapidly after the fuel is dry, leaving a bed of fuel burning with little flame, similar to charcoal. This burns out to a fine light white ash. On the type with inclined coking plates excellent results are secured with lignites. In fact, this type of stoker is admirably adapted to these fuels. The coking plates tip the front part of the fuel bed up at an angle to the hotter portion of the fire and ignition is thus hastened. The incline serves as a drying region, and the stirring action obtained by the fuel cascading over coking plates serves to expose practically all surfaces of the fuel to the drying action of furnace temperatures. The fuel, therefore, reaches the grate ignited and ready for rapid combustion.

With these fuels, extremely high draft is not essen-

*From a paper presented before the Stoker Manufacturers' Association.

tial for high combustion rates, as it is possible to burn liberal amounts of "coal as fired" per square foot of grate per unit of draft. Below is a rough estimate of the relation of the draft in the furnace to the combustion rates of coal as fired:

Lb. coal as fired per sq. ft. of grate surface per hour	Furnace draft, inches of water
10	0.06
20	0.15
30	0.25
40	0.37

In all calculations of draft involving areas of boiler passes, flues and chimneys, allowance must be made for the high rate of coal per horsepower which prevails with these fuels. For instance, if Malskoff lignite containing 7124 B.t.u. is burned at 71.3 per cent efficiency, it requires 6.6 lb. of coal as fired per horsepower developed. All calculations should therefore be based on horsepower developed. It has only been within the last 5 yr. that furnaces have been developed to burn these fuels successfully. Moreover, so little has been said regarding this development that many are still uninformed regarding the results that can be obtained from these high-moisture fuels.

A typical analysis of North Dakota lignite follows:

Moisture, per cent	41
Volatile, per cent	24
Fixed carbon, per cent	27
Ash, per cent	8
B.t.u. (commercial)	6,241
B.t.u. (dry basis)	11,932

On account of its high moisture content, no successful commercial method has been found for burning this fuel. Large areas of it are waiting for the further development of the art of combustion.

That part of the Dakota lignite field which extends beyond the Canadian border, however, bears lignites enough lower in moisture to make possible their successful combustion. The lignite of this field is called "Souris lignite." A typical analysis follows:

Moisture, per cent	29.7
Volatile, per cent	30.3
Fixed carbon, per cent	31.0
Ash, per cent	9.0
B.t.u.	10,770

This fuel is being successfully burned in many plants equipped with chain grates. Large grate areas are, of course, necessary. The ratio usually is at least 1 sq. ft. of grate area for each 30 sq. ft. of water-heating surface. A type of furnace successfully burning this fuel is shown in Fig. 2.

There are some important elements in this furnace which may be discussed:

First, a liberal igniting arch must be provided.

Second, there should be a vertical bridge wall or preferably an arch at the rear, reflecting the heat forward and deflecting the gases forward over the fuel. Such a furnace will ignite and burn 30 lb. of Souris lignite per sq. ft. of grate area per hour.

Colorado Lignites

These do not contain so much moisture as the others discussed; 30 per cent is about the maximum percentage

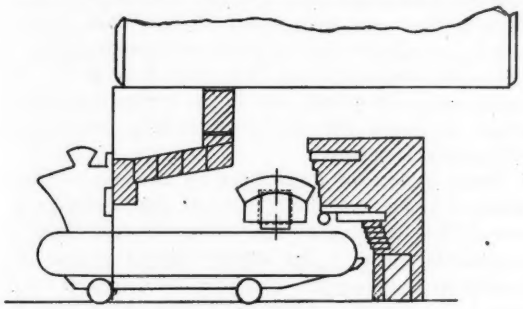

FIG. 2

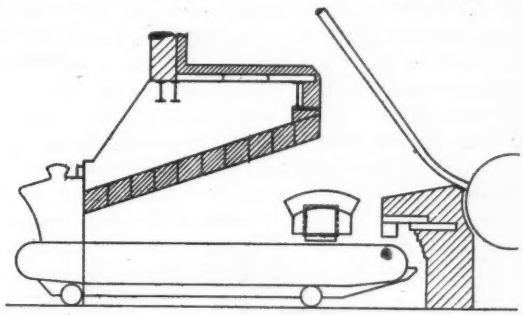

FIG. 4

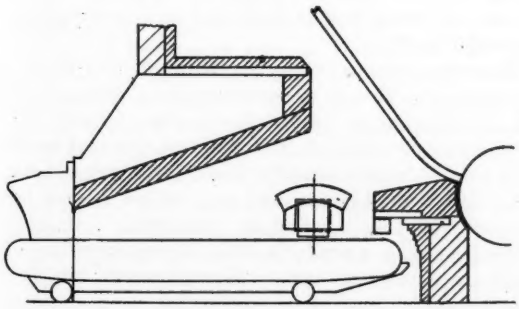

FIG. 3

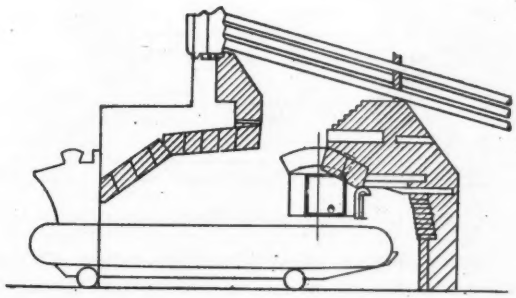

FIG. 5

FIG. 2. A TYPE OF FURNACE SUITABLE FOR NORTH DAKOTA LIGNITE. FIG. 3. TYPE OF FURNACE WELL ADAPTED TO THE BURNING OF COLORADO LIGNITE. FIG. 4. SECTIONAL SIDE ELEVATION OF FURNACE USED FOR BURNING LIGNITE AT PLATTE ST. STATION OF THE DENVER RAILWAY CO. FIG. 5. DESIGN OF FURNACE DEVELOPED FOR TEXAS LIGNITE.

of moisture found in fuel of this district. Pike View lignite, an analysis of which is given below, is typical. Danville lignite contains a higher percentage of ash and slightly lower moisture than Pike View. Both are found in the Colorado Springs district. Analysis of Pike View lignite is as follows:

Moisture, per cent	23.73
Volatile, per cent	35.25
Fixed carbon, per cent	33.23
Ash, per cent	7.79
B.t.u. (commercial basis)	8,511
B.t.u. (dry basis)	11,116

Several years ago, furnaces were developed that would burn these fuels at good combustion rates, but results from modern furnaces appreciably surpass the rates obtained then. In furnaces that were developed 8 yr. ago, the following results were obtained from Pike View lignites:

Type of stoker	Chain grate
Type of boiler	Water tube
Coal per sq. ft. per hr. actual lb	28
Furnace draft	23.2
CO_2 at damper in per cent	12
Per cent rating developed	128
Combined efficiency	69.7

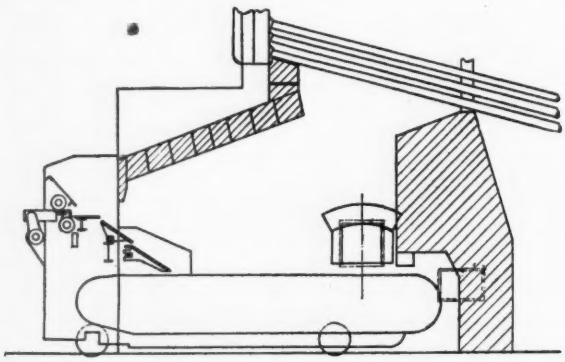

FIG. 6. AN "L" TYPE COKING CHAIN GRATE INSTALLATION

Many plants are using this Colorado fuel. A typical setting installation in one of these plants giving high combustion rates and high efficiencies is shown in Fig. 3.

An Interesting Performance

THE WRITER has recently learned of some excellent combustion rates and general performance with lignite fuel which should be added to our present information. The fuel is Leyden lignite and is mined in Jefferson County, Colorado. The proximate analysis is as follows:

Moisture, per cent	23.08
Volatile matter, per cent	32.43
Fixed Carbon, per cent	32.07
Ash, per cent	12.42
Sulphur, per cent	.20
B.t.u. per lb. as fired	8865

It will be noted that here is a fuel high in moisture (23.08 per cent) and relatively high in ash (12.42 per cent) making the total non-combustible of 35.50 per cent. It is used at the Platte St. station of the Denver Tramway Co. In this installation are six water-tube boilers, each having 7267 sq. ft. of heating surface and fired by two chain grates, each 6½ ft. wide, by 13 ft. long, having a combined grate area of 165 sq. ft. and a ratio of grate surface to heating surface of 1 to 44.

Sectional side elevation of the furnace is shown in Fig. 4. It will be noted that the stokers are long and that the furnace has a long igniting arch, 10 ft. horizontal dimension. The arch is pitched at 4 in. perfect to reflect the heat up to the stoker gate as ignition of this high moisture fuel is one of the most important considerations.

The furnace has 4.7 cu. ft. for each square foot of grate area, which would be enlarged if the installation were being made today.

The units are equipped with superheaters and served by individual induced draft fans with variable speed motors, drawing through economizers.

Results

WITH THIS FUEL, the boilers frequently carry from 250 to 300 per cent rating and 60 lb. of this fuel can be burned per square foot of grate surface per hour.

The thickness of fuel bed carried is 10 in., which gives a substantial fuel bed on the grate, ready to meet sudden demands for steam by simply increasing the draft and stoker speed.

Three important items bear on the combustion performance above described. One is the exclusion of air around the stoker gate and even through the coal in the stoker hopper. The stoker hopper is fed by coal spouts and the hopper is provided with a covering fitted around the spouts. Another unusual procedure is the use of pre-heated air under the stokers. This air is drawn from the basement which in turn draws air from the turbine room and is delivered under the grates at about 80 deg. F.

The other item of interest is the preparing of the coal for burning. This is sometimes called "tempering the coal." The coal is crushed to the size of about 1¼-in. screenings, and although it contains 24 per cent moisture when mined, approximately 5 per cent more water is added by sprinkling the coal just before it goes to the crusher. Wetting the fuel or "tempering" it, as commonly termed, is a matter worthy of consideration. The benefits are physical rather than chemical, but have a most important bearing on combustion rates.

Below is a tabulation of typical performance under the stated conditions:

Type of boiler	Watertube
Type of grate	Chain grate
Heating surface of boiler, each	7267 sq. ft.
Grate surface	165 sq. ft.
Ratio of GS to HS	1 to 44
Furnace volume per sq. ft. of grate	4.7 cu. ft.
Name of fuel	Leyden, Colo., Lignite
Proximate Analysis:	
Moisture	23.08
Volatile matter	32.43
Fixed carbon	32.07
Ash	12.42
Sulphur	.20
B.t.u. per lb. as fired	8865
Combustible in ash, per cent	10.68
CO_2 at damper, per cent	15
Hp. developed in boiler	1920
Per cent rating	273

Hp. developed per sq. ft. grate surface	11.6
Kw.-hr. generated at 14-lb. water rate	8200
Kw.-hr. per rated b.hp	5.83
Coal per sq. ft. of grate surface per hour	60.9

These results were not obtained from an evaporative test but from daily operation and are substantiated by steam flow meter readings, coal weights and electrical load carried. From this standpoint these results should carry more weight than simply an evaporative test under carefully supervised test conditions.

Texas Lignites

Many of these lignites have been burned with excellent results on chain grates. A design of furnace developed for these fuels is shown in Fig. 5. This furnace has, in addition to the ignition arch, a reversed arch from the bridge wall, bringing the heat forward over the fuel bed. Some typical data concerning the characteristics of this fuel and its combustion with this furnace follow:

	Malakoff	Treadlow
Moisture, per cent	29.93	29.80
Volatile, per cent	30.96	31.34
Fixed carbon, per cent	25.45	23.71
Ash, per cent	11.66	13.15
B.t.u. (commercial)	7,124	6,906
B.t.u. (dry basis)	10,314	9,838
Type of stoker	Chain-grate	Chain-grate
Type of boiler	Water-tube	Water-tube
C_2O at damper, per cent	11.81	12.2
Coal per sq. ft. per hr., lb.	30.6	31.6
Draft in furnace	32	24
Combined efficiency, per cent	71.3	69

Some interesting results have been obtained with the "L" type coking chain grate. Such a grate, shown in Fig. 6, has, in addition to the usual horizontal chain-grate surface, an inclined coking plate, approximately 3 ft. in length. When burning lignites this inclined surface serves as an excellent drying zone. Tipped up as it is at an angle to the hotter portion of the fire at the rear, drying progresses rapidly so that by the time the fuel has reached the horizontal chain surface the moisture has been driven off and the fuel has become thoroughly ignited. This method of burning lignites offers possibilities.

Using the same type of furnace as shown in Fig. 6, the inclined coking-plate stoker gives results like these:

Name of fuel	Calvert (Tex.) Lignite
Moisture, per cent	30.16
Volatile, per cent	38.33
Fixed carbon, per cent	24.03
Ash, per cent	7.48
B.t.u. (commercial)	7,462
B.t.u. (dry basis)	10,669
Kind of boiler	Water-tube
Kind of stoker	"L" type chain grate
Coal per sq. ft. of grate per hr., lb.	36.4
Furnace draft	.34
CO_2 at damper, per cent	11.2
Combined efficiency, per cent	67

Considering that the moisture content of these fuels is from 25 per cent to 30 per cent, the efficiencies of from 69 per cent to 72 per cent are creditable, as it is evident that it is not possible to obtain the high efficiencies from these fuels that can be obtained from low moisture fuels. Such fuels as Calvert lignite with 30 per cent moisture require 372 B.t.u. per pound simply to evaporate the moisture which is in the fuel and heat the resultant steam to a temperature of 500 deg. F. (assuming a temperature in the boiler room of 80 deg. F.) The heat thus used is 5 per cent of the total heat in the fuel as fired and must detract directly from the efficiency of steam generation.

Soldering Lugs to Leads

Much difficulty is frequently encountered by the man of limited electrical experience in soldering lugs to leads.

In reality, this is a sweating process and may be done in the following manner: After having removed from the end of the lead to which the lug is to be fitted a length of the insulation equal to the depth of the lug, clean the exposed strands well with sandpaper, cover with a thin coat of so-called "soldering paste" or other flux and dip into molten solder. In this way, the lead will become well "tinned."

The lug is then placed in a vertical position with the open end upward by clamping between the jaws of an ordinary bench vise. To obtain good results and a satisfactory and well holding joint, the cavity of the lug must also be cleaned bright by means of sandpaper, after which apply with a small swab a thin coating of flux as was done in the case of the lead.

Both lead and lug are now ready for sweating. If these are of considerable size, they should be well heated, which may be done by the application of the flame of a blow torch. When up to the required temperature, molten solder is poured into the cavity of the lug and the bare end of the lead plunged into the solder and held securely in place until the solder not only solidifies, but becomes comparatively cool. This may be hastened, much time saved and burning of the adjoining insulation prevented by applying to the joint a piece of cotton waste well saturated with water.

To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains 14 Research Graduate Assistantships in the Engineering Experiment Station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600, are open to graduates of approved universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry. An appointment to the position of Research Graduate Assistant is made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Nominations to these positions are made from applications received by the Director of the Station each year not later than the first day of March. Preference is given those applicants who have had some practical engineering experience. Additional information may be obtained by addressing the Director, Engineering Experiment Station, University of Illinois, Urbana, Ill.

The Centrifugal Pump

ITS THEORY OF OPERATION; SELECTION OF UNITS; DRIVES AND INSTALLATION. BY R. A. FISKE

THE centrifugal pump as placed upon the market today has been so highly perfected in design and improved in efficiency that it is now worthy of serious consideration for practically any class of pumping service. About the only exceptions to the above as to adaptability are—the high-pressure hydraulic press and deep well service.

The advantages to be expected from this type of pump are: (1) But one moving part; (2) no valves or pistons to be kept in order; (3) uniform pressure and flow of water; (4) freedom from shock; (5) compactness; (6) simplicity of design; (7) simple to operate and repair; (8) high rotative speed, allowing direct connection to electric motors and steam turbines; (9) in case of stoppage of delivery, the pressure cannot build up beyond predetermined working limits; (10) low first cost; (11) low rate of depreciation.

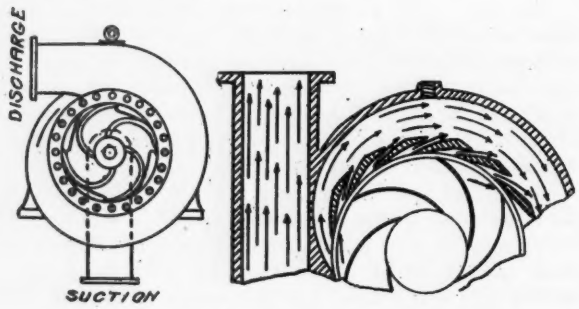

FIG. 1. VOLUTE TYPE OF CENTRIFUGAL PUMP

FIG. 2. PARTIAL SECTION, TURBINE TYPE OF CENTRIFUGAL PUMP

The disadvantages are: (1) The rate of flow cannot be efficiently regulated for wide ranges in duty; (2) the efficiency is not as high as the best grade of piston pump; (3) direct connection to low-speed engines cannot be made when operating on high lifts.

THEORY OF OPERATION

THE PRINCIPLE upon which the centrifugal pump is based is that of centrifugal force imparted to the water by means of a bladed impeller rotated in an inclosed casing. The general classification of centrifugal pumps is:

1. Volute—which in its ordinary form is made with a single impeller and without guide vanes in the casing. With the closed type of impeller, a double inlet is used, thus eliminating side thrust.

2. Turbine or multi-stage pumps—in which inclosed type of impeller is used with diffusion vanes introduced in the casing to direct the flow from the runner.

The theory of the diffusion vanes is that they increase the efficiency by transforming a larger portion of the kinetic energy at the outlet of the impeller, to the pressure form and so reduce the loss of head in the casing.

The single runner pump may be efficiently used for heads up to and including 150 ft. or higher, with efficiencies of from 50 to 80 per cent. For pressures above 50 lb. per sq. in., two or more runners or stages may be used, each stage adding approximately 50 lb. per sq. in. to the total pressure available from the pump.

For best efficiency, the centrifugal pump must be properly designed as to curvature of vanes, diameter and speed of impeller, number of stages, etc. As an example, a boiler feed pump which operates under practically a constant head should be designed so that the driving unit will be protected against possible overloads. General water supply pumps would be another example of this kind. The efficiency of this type of pump is quite a variable quantity, depending primarily upon the head against which it operates. It follows, then, that the characteristics of each installation should be carefully studied and all facts presented to the pump builder; then, when installed, if the pump is expected to deliver a stated speed and power consumption, the conditions under which the pump was rated must be reproduced in practice.

SELECTION OF UNITS

THE ENGINEER charged with the selection of a centrifugal pump will do well to co-operate fully with the pump builder and furnish the latter with accurate data as to: (1) Capacity of pump—gallons per minute; (2) total lift, including discharge and suction head as well as pipe friction; (3) variations in lift, both suction and discharge; (4) type—horizontal or vertical; (5) quality of liquid, fresh water, gritty or solids in suspension; (6) temperature of liquid; (7) specific gravity of liquid; (8) service; (9) motive power to be used.

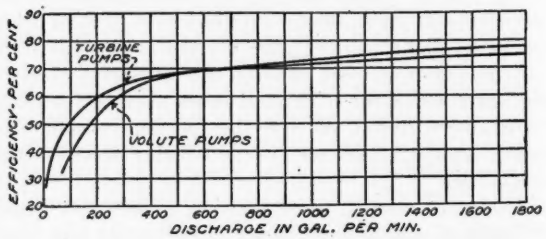

FIG. 3. EFFICIENCY—CAPACITY CURVES OF TURBINE AND VOLUTE TYPE PUMPS

The capacity of a proposed pump may be determined from the known rating of a pump being replaced or from carefully compiled data as to requirements. Immediate future requirements should be investigated both as to pressure and capacity of the pump, and increased steam pressure in the case of turbine drives. These requirements might be brought about by the installation of modern boiler equipment operating at high pressure.

The character and location of a pump installation will determine the suction lift, discharge pressure and friction load. Variation in suction lift and discharge pressure must be arrived at by observed data.

In making a pump selection, several properties frequently overlooked should be borne in mind; as—two

single-stage pumps each capable of delivering 500 gal. at 75 ft. head, connected in series will deliver 500 gal. at 150 ft. head. The same pumps connected in parallel will deliver 1000 gal. at 75 ft. head. Another point worth bearing in mind is that a centrifugal pump never loses any head that may be received by it at the suction chamber. For instance: if a pump capable of delivering water at 200 ft. head receives it at 100 ft. head it will discharge the water at 300 ft. head. Further, when two or more equally rated centrifugal pumps discharge into a common main their characteristics should be the same; otherwise, under certain conditions of head, they may not give equal delivery and there is the possibility of one pump cutting out altogether.

Drive

The centrifugal pump may be driven by belt or ropes, by the steam turbines or the electric motor. The belt or rope drive is used only when direct connection cannot be advantageously employed. This mode of drive would be desirable to retain the advantages of a high-speed pump driven by a slower running driving agent.

The steam turbine when exhausting into a vacuum offers a very economical drive. In such units the turbine may exhaust into a condenser serving one or several of the main generating units. The exhaust may be used to advantage in feed water heaters. Where economizers are installed and where there would otherwise be an excess of auxiliary exhaust, low-pressure turbines could be used as drivers, the low-pressure steam being derived from other auxiliaries or from the intermediate receivers of the main engines or turbines. The turbine can also be arranged to exhaust into the intermediate stages of the main generating units. In the larger units, it may prove advantageous to use a low level jet condenser, taking the condensing water from the discharge side of the pump and returning the waste water to the suction well.

Surface condensers of the water-works type may be placed either on the suction or discharge side of the pump, using the delivery of the pump as the cooling water. The first cost of the surface condenser is, of course, high.

One great advantage of the steam turbine driven pump is that its delivery may be throttled down to zero when the pump is operating at normal speed.

The electric motor as a drive for centrifugal pumps has particular advantages in isolated installations or where no facilities are at hand for taking advantage of the heat available in the exhaust steam. Direct-current motors find application in plants where only direct current is available or where adjustment of speed is necessary. The direct-current motor has the further advantage in that it can be designed for any definite speed.

Where the voltage is constant either shunt wound or the compound wound, direct current motor can be used with success. Where the voltage is variable, as in some temporary installation, particularly when fed from an electric railway circuit, a compound direct-current motor should be used. It is generally recommended that when direct-current motors are used the discharge gate valve be closed in starting. This procedure should especially be used with shunt wound motors. Proper ventilation must not be overlooked in motor driven installations.

The synchronous motor is coming into quite common use for driving centrifugal pumps. This is due to their possibilities of maintaining or correcting the power factor of the system to which they are connected. The induction type of polyphase motor is well adapted for direct connection to centrifugal pumps. This is due to simplicity of installation and operation, and the comparatively wide range of speed and output which may be obtained from them.

The squirrel-cage motor has a certain definite limit to the starting torque it will develop. This type of motor cannot be started by connecting it directly across the lines, except in the small sizes. In this respect, it is similar to the direct-current motor in that wide fluctuations in voltage will be caused by the rush of current, as well as dangerous shocks administered to the motor and excessive demands of current at low power factor placed upon the generating equipment. The general method of starting is to apply reduced voltage to the primary member and when the rotor is up to speed throw over the full line voltage.

Starting compensators should be provided for all motors over 5 hp. It is imperative that the discharge gate valve be closed when starting although it is possible to start the pump with the discharge valve open, but the excessive current required at starting in time will cause trouble with the motor.

The starting torque of the slip-ring motor can be varied by inserting resistance in the rotor, the power factor remaining the same as though the motor were actually running under the starting loads. This type of motor is preferable in units of the larger sizes on account of its ability to start up smoothly under a hard or heavy load.

The squirrel-cage motor is well adapted to centrifugal pump drives, because of simplicity of motor and control; the first cost is generally less than that of the slip-ring type. Due to the squirrel-cage motor's characteristic of low starting torque, a valve should be placed in the discharge line for unloading purposes during the starting period.

In the selection of a pumping unit it is always best to obtain bids from several manufacturers; study over the bids carefully; tabulate them in so far as the primary features are concerned; make a careful comparison of details as to ease of dismantling, method of lubrication, size and construction of bearings, materials used, and the general ruggedness and serviceability of the pump as a unit.

It is generally conceded that the flexible joint is not all that it should be on high-speed shafts; therefore, a rigid baseplate extending under pump, driving unit and gears, should be provided to keep the unit shafts in good alinement.

Since the average engineer will not buy a great deal of centrifugal pump equipment, it is a good practice to obtain a list from the manufacturers of installations similar to the one contemplated, visit the plants where these units are operating, and your time will be well repaid in information derived from the man on the job.

In the final selection, too much emphasis should not be put on price until the purchaser has become satis-

fied as to adaptability, construction, serviceability, and in some cases the time of delivery.

It often happens that the driving unit selected is not manufactured by the pump builder. The latter is always willing to quote upon any standard driving unit required. This brings up the point as to whether or not the purchaser can make a saving by buying the driving unit direct from the manufacturers and having it shipped to the pump manufacturer and assembled to the pump by the latter, thus saving the carrying charges expected by the pump builder. The answer to this is, avoid divided responsibility, let the pump builder furnish the entire unit, and then hold him alone responsible for its effectiveness.

Installation

When installing a centrifugal pump, provide a foundation sufficiently substantial to support the pump rigidly. Carefully line up the driving unit and pump before grouting or drawing up foundation bolts. Check alinement again after tightening up.

If possible, do not make the suction lift, including friction, more than 15 ft.; 20 ft. is about the maximum lift for good operating conditions. Avoid unnecessary bends or sources of friction in the suction pipe. The suction piping should be one size larger than the pump connection: the connection should be made with an eccentric reducer to avoid air-pockets. Elbows should be avoided at the suction connection of the pump.

The suction line must be free from air leaks and places where air pockets will form; if the latter are formed, some means must be devised of relieving them of air when it collects.

An effective check valve as well as a gate valve should be placed in the discharge line, both to be located as near the pump as possible. In shutting down the pump, in cases where there is a foot valve and possibility of a water hammer, it is advisable that the discharge valve be closed before shutting off the power.

If the water handled by the pump is dirty and gritty, the sealing pipes should be supplied with clear water from an exterior source. On boiler feed pumps it has sometimes been found best to use cold water in the packing glands, and in this way the only heat in the stuffing-box is that due to its own friction.

It is not advisable to try to operate direct-acting and centrifugal pumps in parallel.

Acceptance tests should be run, if feasible, or an engineering representative of the purchaser can be present at shop tests conducted by the manufacturer. The shop tests should conform to the conditions as stated in the specifications. This is important in boiler feed pump tests. The shop test should be made, using water at the temperature at which the pump will handle it when permanently installed.

An article published recently in one of the technical journals in Berlin describes the great success which has been attained in the use of raw coal tar instead of tar oil for driving Diesel motors. When cleansed by filtering, and raised to a temperature of 60 deg. C. before use, the tar gives perfectly good results.—Gas Journal.

How to Make Pipe Bushings Out of Standard Pipe*

By W. F. Schaphorst

IT IS a good thing to know that bushings can be made out of standard pipe. Many pipe fitters don't know that it can be done; or, if they know that it can be done, they don't know the correct size of drill to use for tapping. I have known for many years that it can be done and have occasionally made bushings out of pipe; but each time I found it necessary first to look into my handbook for the drill size to use and that is so much trouble that it is frequently easier to go to the store and buy a new bushing. Recently, though, it has been very difficult to buy bushings in stores on account of shortage of all pipe fittings, hence I feel that the following information should be of much value. I have collected all of the data together for all bushings that can be made out of ordinary sizes of extra heavy and double extra heavy piping.

To bush from ¼ to ⅛ in., for example, get a piece of ¼-in. extra heavy pipe sufficiently long for cutting the outside thread. Then cut the end off to the desired length, drill or ream with a 21/64-in. drill (diameter of drill 0.328 in.) and then tap with a ⅛-in. pipe tap. That's all there is to it.

The table herewith tells the complete story for all ordinary sizes. Note that in one case, ⅜ to ¼-in., the internal diameter of ⅜-in. extra heavy pipe is such that no drilling is necessary.

Also note that in bushing from ½ to ⅜ in., either extra heavy or double extra heavy piping can be used.

To Bush From	Use This Size of Pipe	Use This Size Drill or Reamer
¼″ to ⅛″	¼″ Extra Heavy	21/64″ Drill — 0.328″
⅜″ to ¼″	⅜″ Extra Heavy	None
½″ to ⅛″	½″ Double Extra Heavy	21/64″ Drill — 0.328″
½″ to ¼″	½″ Double Extra Heavy	27/64″ Drill — 0.422″
½″ to ⅜″	½″ Double Extra Heavy	9/16″ Drill — 0.562″
½″ to ⅜″	½″ Extra Heavy	9/16″ Drill — 0.562″
¾″ to ⅜″	¾″ Double Extra Heavy	9/16″ Drill — 0.562″
¾″ to ½″	¾″ Double Extra Heavy	11/16″ Drill — 0.688″
1″ to ¾″	1″ Double Extra Heavy	29/32″ Drill — 0.907″
1¼″ to 1″	1¼″ Double Extra Heavy	1⅛″ Drill — 1.125″
1½″ to 1″	1½″ Double Extra Heavy	1⅛″ Drill — 1.125″
1½″ to 1¼″	1½″ Double Extra Heavy	1 15/32″ Drill — 1.468″
2″ to 1½″	2″ Double Extra Heavy	1 23/32″ Drill — 1.72 ″
2½″ to 2″	2½″ Double Extra Heavy	2⅜″ Drill — 2.187″
3″ to 2½″	3″ Double Extra Heavy	2⅝″ Drill — 2.562″
3½″ to 3″	3½″ Double Extra Heavy	3⅜″ Drill — 3.187″
4″ to 3½″	4″ Double Extra Heavy	3⅝″ Drill — 3.688″
4½″ to 4″	4½″ Double Extra Heavy	4⅜″ Drill — 4.187″

Well, He's No Quitter

Dennis was a helper around the yard at the power house, a willing worker, but he had not as yet become familiar with things in general. The chief electrician requested him to go over to the stock room and bring him one dozen new brushes. The storekeeper was out when Dennis arrived, but as the boss was in a hurry, Dennis looked things over.

Dennis returned, carrying a tin pail, and approaching the C. E. said: "I'm sorry, sor, but this was the only brush there and shure 'twas stuck so dom tight in the can I brought 'em both."

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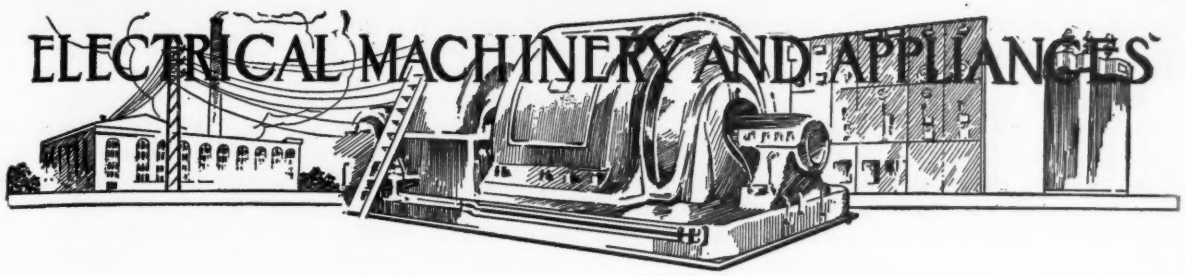


Remodeling Switch Gears for Power Systems---II

TYPE OF OIL CIRCUIT BREAKERS AND RELAYS EMPLOYED; EXAMPLE OF TYPICAL RELAY SYSTEM. BY STEPHEN Q. HAYES*

FOR voltages higher than 25,000, compartment construction is seldom used and breakers are furnished with individual steel tanks for each pole.

These breakers are available for all voltages from 22,000 to 155,000 v., indoor or outdoor, manual or electrically operated. They are available for frame mounting up to and including 73,000 v. With interrupting capacities of from 1440 to 5350 amp. per phase at rated voltage available with different types, the requirements of present high voltage systems are well met with this line of breakers.

The main oil circuit breakers used for power transmission service are supplied either indoor or outdoor, depending on whether the transformers with which they are employed are arranged for indoor or outdoor service.

Practically all such breakers are arranged for sole-

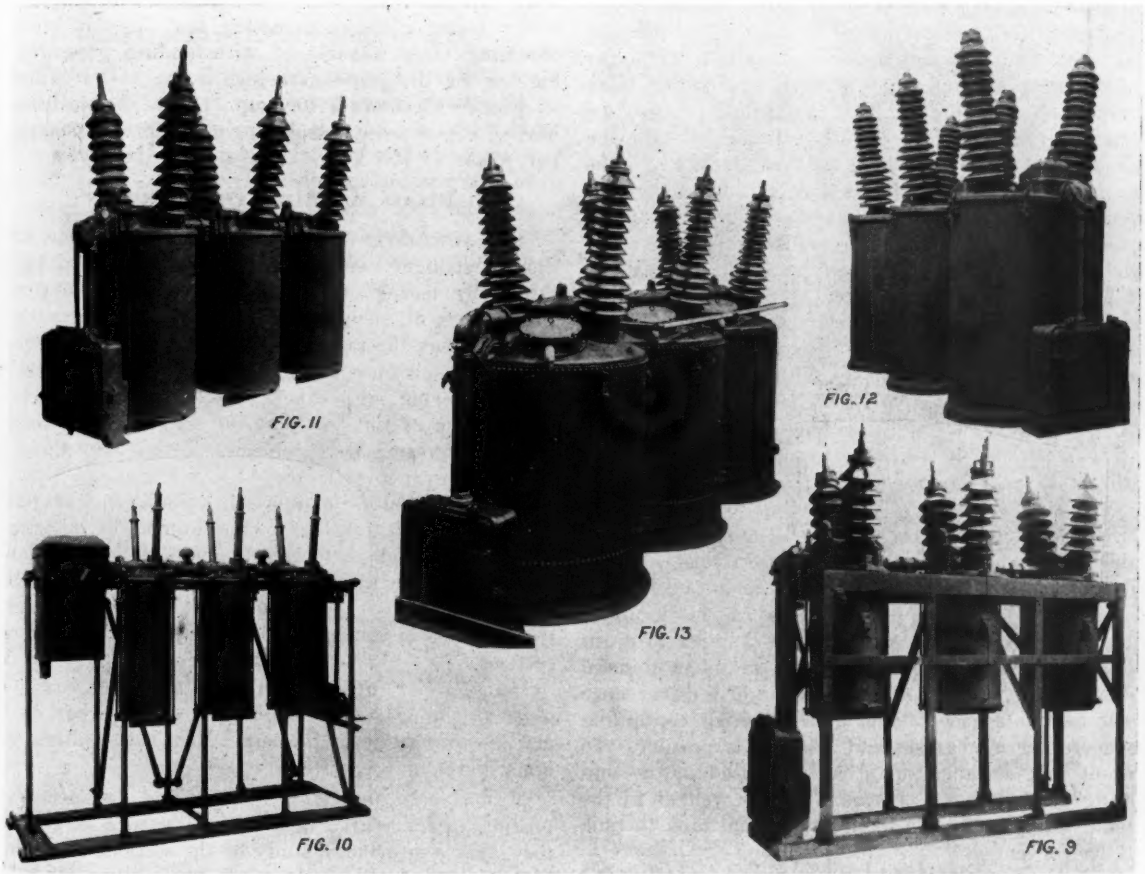


FIG. 9. TYPICAL 73 KV. SOLENOID OPERATED BREAKER FOR OUTDOOR MOUNTING. FIG. 10. TYPICAL 37 KV. OIL CIRCUIT BREAKER FOR INDOOR SERVICE. FIG. 11. OUTDOOR PLATFORM MOUNTED BREAKER RATED AT 95 KV., 400 AMP. FIG. 12. 135 KV. OUTDOOR BREAKER WITH RUPTURING CAPACITY OF 1600 AMP. FIG. 13. THREE POLE BREAKER RATED AT 135 KV. 400 AMP.

*Electrical Eng., Westinghouse Electric & Manufacturing Co.

noid operation as three-pole units, and most of them are built with a separate steel tank for each pole of each breaker.

Practically all of the high-tension breakers can be made suitable for either indoor or outdoor service, but are usually supplied for outdoor. Up to 73 kv. the high-tension oil circuit breakers, whether for indoor or outdoor service, are usually made for frame mounting to permit the tanks to be dropped easily to secure rapid inspection and adjustment of the contacts.

Figure 10 shows a 37 kv. breaker for indoor service and clearly illustrates the pipe framework used for supporting the breaker at such a height that the tanks can readily be dropped. The difference between the indoor and outdoor breakers lies chiefly in the porcelain rain shields over the bushings and the weather-proof covering of the mechanism.

Figure 9 shows a 400-amp., 73-kv. solenoid operated outdoor frame mounting oil circuit breaker having a guaranteed rupturing capacity of 1700 amp. at 73 kv. This breaker has elliptically shaped oil tanks made of steel plate with lap welded seams and a cast steel top of domed shape to secure ample strength against explosion. The tanks are arranged for suspension from the supporting frame and are hung by suitable tie bolts connected to a supporting grid beneath the tank. An overhung lip around the top is interlocked with the tank rim and suitable packing between the top and the rim insures waterproof joints. A suitable removable cover with interlocking rim gives access to the upper portion of circuit breaker mechanism. Conduit pipe with packing washers and lock nuts affords weatherproof communication from pole to pole for the operating levers and for the control leads when required. Solenoid operated mechanism is located at one end of the unit, housed in a case or box with a removable cover having packed joints. This box has conduit pipe for connection to the circuit breaker mechanism.

The steel top, in addition to supporting and protecting the operating mechanism, is arranged to form an expansion chamber to cushion the pressure caused at the instant of interrupting the circuit. As considerable oil vapor and gas may collect in this chamber, suitable baffled vents are placed in such positions as to relieve sudden air pressures, and in addition, to induce circulation of air through the chamber to drain out the accumulating oil vapor. As the oil is of more or less volatile nature, the transmission of a disturbance in one tank to adjacent tanks and to the box containing the operating mechanism and solenoid is possible. To prevent this, suitable baffles can be placed in the connecting conduit pipe. Pressure can be vented to the outside, but propagation of pressure from tank to tank will be prevented.

The terminal bushings are sufficiently protected by petticoated insulators to afford insulation under the most severe conditions of weather.

On circuit breakers of small and moderate size where the weight of the oil tanks and oil is not prohibitive, the frame mounting arrangement of circuit breaker is highly desirable, as it permits the ready removal of the oil tanks for the purpose of inspecting the contact details and the operating mechanism without disturbing the line connections.

Breakers for higher voltages and larger rupturing capacities are usually made platform mounting, owing to the difficulty of lowering the tank filled with oil.

With the larger breakers, access to the interior of the tanks is secured by the removal of the mechanism cap which exposes the lever system and presents a sufficiently large opening to withdraw any necessary part. The mechanism is ordinarily so arranged that a terminal bushing complete with its contact details can be withdrawn without disturbing any other details, and the moving contact elements can also be withdrawn through the manhole or mechanism cover.

A typical outdoor platform mounted breaker is shown in Fig. 11, which illustrates a 95-kv., 400-amp. breaker with elliptical tanks having a guaranteed rupturing capacity of 2400 amp. at 95 kv.

Figure 12 shows the 400-amp., 135-kv. electrically operated oil circuit breaker having a guaranteed rupturing capacity of 1600 amp. at 135 kv.

Where even greater rupturing capacities are desired for high voltage service, the circuit breaker tanks are made circular with domed top and bottom employing heavy boiler plate construction and in this manner obtaining tanks capable of withstanding pressures as high as 150 lb. per square inch.

Figure 13 shows a 400-amp., 135-kv. 3-pole breaker having a guaranteed rupturing capacity of 4300 amp. per phase at 135 kv.

Relays for Automatic Operation

For automatic operation various features in addition to straight overload tripping can be readily obtained by means of suitable relays, and the proper functioning of such relays is of vital importance in large systems for taking care of overload or short circuit conditions on a certain section of the system without interfering with other sections, and the question of relay protection is therefore intimately connected with all transmission problems, particularly those on rapidly growing systems.

The principal use of relays in connection with power transmission is to give to the automatic oil circuit breakers other characteristics than those of plain overload in order to facilitate the disconnecting of disabled sections of transmission lines and to handle properly the various operating problems arising on different systems.

In applying relays, particular attention has to be given to the characteristics of the relays, circuit breakers, generators, transformers, transmission lines and other parts of the system.

It has been found on various long distance transmissions, particularly those spread over a large territory, that a systematic study of the sectionalizing problems and a comparatively small expenditure for relays and slight rearrangement of switching apparatus will greatly improve the service to important customers.

The number of short circuits and grounds per year occurring on any transmission system varies greatly with local conditions, but can be taken roughly as one ground or short circuit per year for each 10 to 15 mi. of line, so that it is to be expected that there would be approximately 100 cases of short circuits or grounds on a transmission system covering from 1000 to 1500 mi.

By proper arrangement of relays on such a system, any trouble is localized and an extensive interruption due to line trouble can usually be avoided.

The proper relaying equipment for use on any transmission line will depend among other things on the type of distribution used. Where there is a single source of power with feeders radiating out from the generating station and possibly passing through one or more sectionalizing or transforming stations, proper

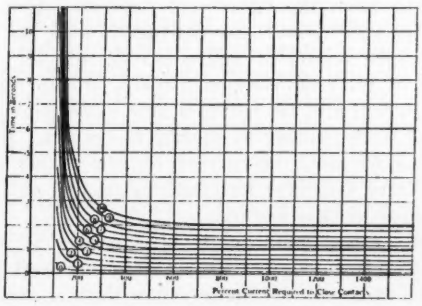


FIG. 14. RELAY CHARACTERISTIC CURVES

selective action can usually be obtained by making the breakers farthest from the power house practically instantaneous in their operation, those at the power house being provided with relays set for a definite time of from 1 to 2 sec. and the intermediate sections being provided with relays having various time settings.

In addition to securing discrimination on the part of the relays by means of a definite time feature, it is also possible to discriminate by the current setting be-

FIG. 15. TIME ELEMENT OVERLOAD RELAY

cause trouble which occurs at the far end of a branch line will not draw as heavy a current as though it were closer to the source of power. Selective action can frequently be obtained to advantage by the use of an inverse time limit relay having characteristic curves similar to those shown in Fig. 14. This type of relay has an adjustable time element in addition to the inverse time, and the combination of these two is well adapted for the protection of circuits of this kind, because either the inverse time part of the curve or the definite time part can be utilized, depending upon the particular circuit standard.

Such combination of definite time and inverse time is obtained in the relay shown in Fig. 15. This relay is built on the induction principle, and its success has been largely due to its remarkable accuracy and permanence of calibration. Use of a permanent magnet as a time limiting device prevents over-swinging and chattering of the contacts, and the construction is such that the relay will instantly cease its movement when the overload disappears.

One of the essential features of this relay is the torque compensator embodied in its design. This is essentially a small current transformer having com-

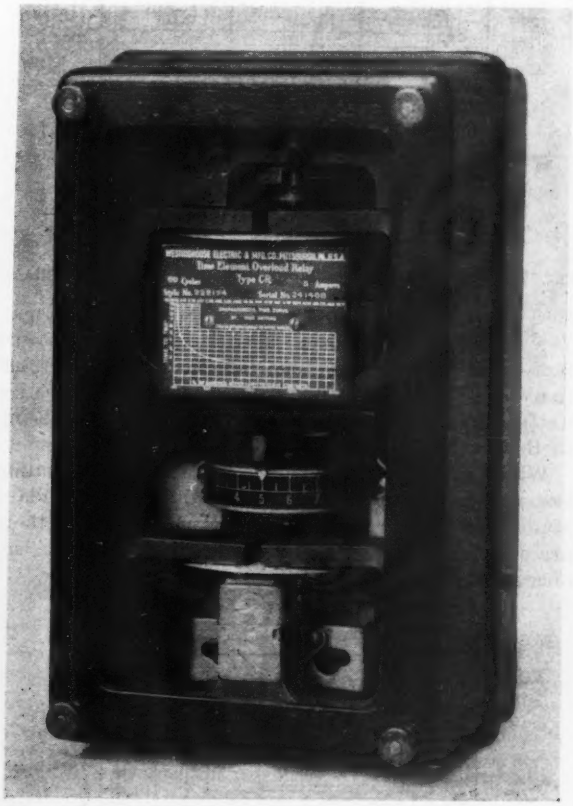


FIG. 16 REVERSE POWER RELAY

paratively little iron in its magnetic circuit so that it saturates at a little more than 5 amp. in the primary. With this device, the primary current can be momentarily increased to 200 times normal without increasing the secondary current more than a small percentage. As it is this secondary current that actually works on the relay mechanism, the force of the relay is practically constant, independent of the amount of the overload so that its speed of operation is independent of the value of the short circuit, and is determined by the restraining influence of the permanent magnet and the distance through which the contact has to move. As this distance is adjustable, the definite time setting on the standard relay can be made anything from 0.1 up to 2 sec., and in special cases up to 4 sec. A current

adjustment is also provided on this relay so as to secure normal operation with relay current varying from 4 to 12 amp.

For the protection of a parallel feeder system or a ring system, reverse power relays are necessary, and these can be made in the form shown in Fig. 16. This relay is essentially a two-element relay, the current element being practically the same as that described above, and having the same overload and time element characteristics. In addition to the current element there is a watt element that closes a contact whenever the

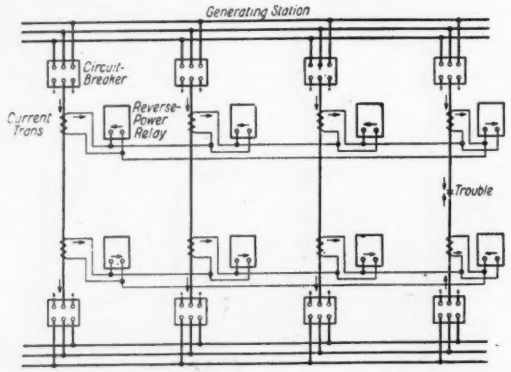


FIG. 17. BALANCED SYSTEM OF CROSS CONNECTED RELAYS

flow of energy is in a reversed direction from normal. The current element closes its contacts on excess current in either direction, but the relay will not function to trip the circuit breaker unless the selective wattmeter element also functions due to the power being in the reversed direction.

While in many cases transmission and distribution systems can be readily sectionalized by the standard application of overload and reverse power relays, there are other conditions that can be best handled by a balanced system of relays.

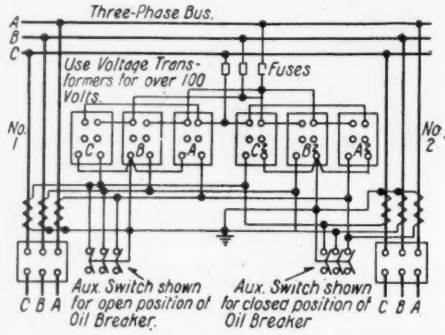


FIG. 18. BALANCED SYSTEM OF CROSS CONNECTED RELAYS FOR 3-PHASE CIRCUIT

In most cases, an arrangement of balancing relays on parallel feeders using the cross connection of reverse power relays will work out to the best advantage. Such an arrangement is indicated in Fig. 17, this showing four circuits between a generating station and a receiving station and omitting the step-up and step-down transmission. This schematic diagram has been simplified by showing only one phase on each of the feeder circuits, the more complete diagrams applying, however, to a pair of 3-phase circuits as shown in Fig. 18.

By reference to these two figures, it will be noted that the current transformers at the generating station are connected in series for each particular phase and similarly at the substation, and that each relay that must be of the reverse power (uni-directional) type is shunted across its own current transformers.

Under normal conditions, the load in each of the parallel feeders will be the same, and since the relays have a higher impedance than the current transformers, the current from the latter will circulate through all of them in series without any flowing through the relays. If the trouble occurs at any point outside the section protected by the cross connected relays, the current over the feeders will still be balanced and consequently there will be no force tending to operate the relays. In other words, a short circuit occurring on some other portion of the system will have no tendency to trip out any of the breakers in this section.

On the other hand, if trouble occurs at a point within the protected sections, the current over the defective circuits will be higher than that in the others, and this excess current from its current transformer

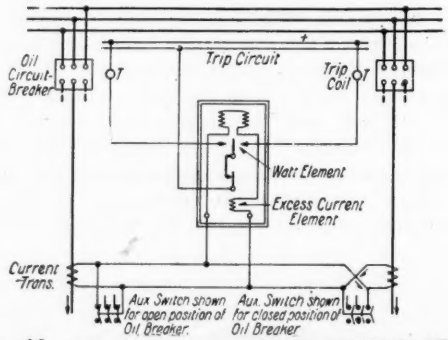


FIG. 19. CONNECTIONS OF DOUBLE CONTACT RELAY

must pass through the relays. While under this unbalanced condition, current will flow through all of the relays, it will be observed that the current is in the proper direction to cause the current to act only in the relays at each end of the defective section as shown by the arrows in the diagram.

As shown in Fig. 18, pallet switches are connected in the transformer secondary circuit and are mechanically operated by the breaker so that when the breaker opens, the current transformers are short-circuited. By this method, a feeder can be cut out of service without interfering with the electrical balance in the current transformer circuits.

Where there are only two parallel feeder circuits, a double contact reverse power relay connected as shown in Fig. 19 can be utilized. This relay is so arranged that in case of trouble, the watt element will close the circuit leading to the trip coil of the breaker in the defective circuit, and the excess current element will operate to trip out that breaker under suitable conditions of overload and time element. More complicated networks can usually be taken care of by proper selection of the type of relays to be employed.

Figure 20 shows the relaying schemes proposed for a moderate sized system with various generating stations and substations to insure continuity of service under varying conditions with the minimum expenditure for

duplicate transmission lines. A rather complete analysis of the equipment proposed is given and the principal generators, transformers, and switching devices have been indicated and numbers have been assigned to the various breakers, those in service being marked "old," those proposed for the new equipment being marked "new."

The dotted lines show the second 33,000-v. transmission line running between the generating station No. 1, and substation No. 2, and future transformers supplying the energy to that line are indicated. These transformers should preferably be of the same capacity, regulation and reactance, as the present two 2500-kv.a. transformers, so that the total reactance between the 6600-v. two-phase bus at generating station No. 1 and the 33,000-v. three-phase high-tension bus at substation No. 2 should be practically the same over either of the two lines in order to secure suitable balanced protection.

No 33,000-v. breakers have been shown on the high tension side of the transformer banks at generating station No. 1 and substation No. 1 and no 13,200-v. breaker has been shown on the high-tension side of the three 1000-kv.a. 2300/13,200-v. transformers at generating station No. 2. The breakers on the low tension side of these transformer banks will furnish all of the automatic protection desired for such circuits.

On Fig. 20, the ratio of the current transformers and the time setting of the various relays is not marked, but the desired ratios and time settings can be selected to secure the desired automatic sectionalizing of the circuits in case of trouble on any transmission line.

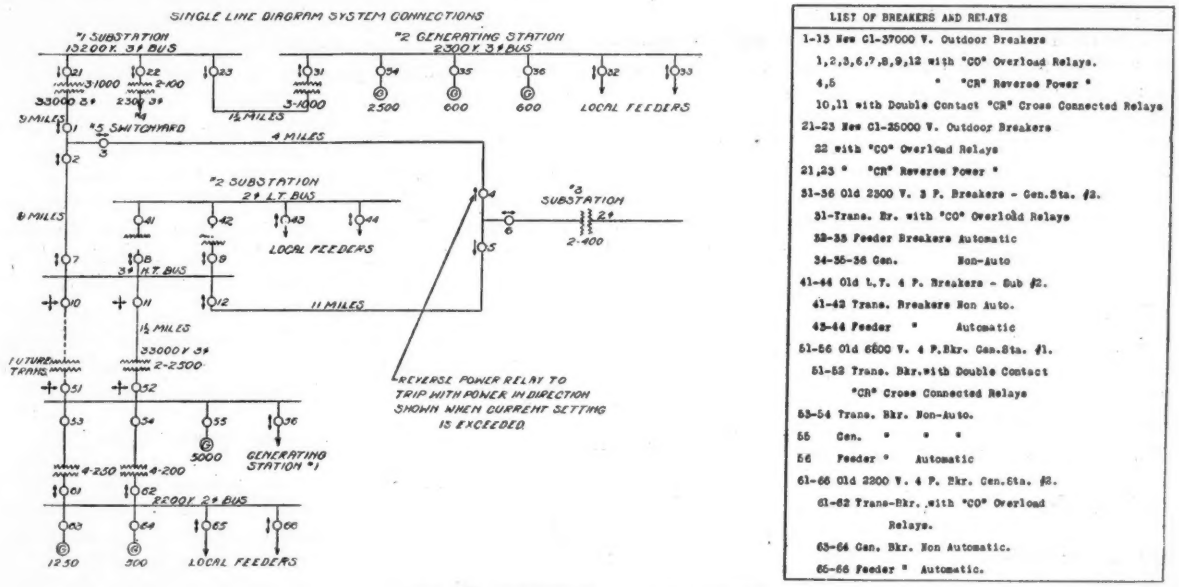

SINGLE LINE DIAGRAM SYSTEM CONNECTIONS
"1 SUBSTATION 13200 V. 3 ϕ BUS
"2 GENERATING STATION 2300 V. 3 ϕ BUS
LOCAL FEEDERS
"1 SWITCHYARD
4 MILES
"2 SUBSTATION 2 ϕ L.T. BUS
"3 SUBSTATION
LOCAL FEEDERS
H.T. BUS
11 MILES
1½ MILES
FUTURE TRANS.
REVERSE POWER RELAY TO TRIP WITH POWER IN DIRECTION SHOWN WHEN CURRENT SETTING IS EXCEEDED
GENERATING STATION "1
2300 V. 2 ϕ BUS
LOCAL FEEDERS
LIST OF BREAKERS AND RELAYS
1-13 New Cl-37000 V. Outdoor Breakers
1,2,3,6,7,8,9,12 with "CO" Overload Relays.
4,5 " "CR" Reverse Power "
10,11 with Double Contact "CR" Cross Connected Relays
21-23 New Cl-25000 V. Outdoor Breakers
22 with "CO" Overload Relays
21,23 " "CR" Reverse Power "
31-36 Old 2300 V. 3 P. Breakers - Gen.Sta. #2.
31-Trans. Bkr. with "CO" Overload Relays
32-33 Feeder Breakers Automatic
34-35-36 Gen. Non-Auto
41-44 Old L.T. 4 P. Breakers - Sub #2.
41-42 Trans. Breakers Non Auto.
43-44 Feeder " Automatic
51-56 Old 6600 V. 4 P.Bkr. Gen.Sta. #1.
51-53 Trans. Bkr.with Double Contact "CR" Cross Connected Relays
53-54 Trans. Bkr. Non-Auto.
55 Gen. " " "
56 Feeder " Automatic
61-66 Old 2300 V. 4 P. Bkr. Gen.Sta. #2.
61-62 Trans-Bkr. with "CO" Overload Relays.
63-64 Gen. Bkr. Non Automatic.
65-66 Feeder " Automatic.

FIG. 20. RELAYING A LARGE SYSTEM

Ring Fire and Flashing

By O. P. Forster

"RING FIRE" is the designation which has been given to that kind of sparking where rings of "fire" (electric arcs) embrace the circumference of the commutator, wholly or partially encircling it. Ring fire may be subdivided into two classes: (1) Ordinary ring fire. This is of a reddish tint and it may exist, to a limited extent, on all commutators. (2) Armature-defect ring fire. This is of a bluish-green color and is more intense than that of the ordinary class.

Ring fire is originated ordinarily by minute arcs which form between adjacent commutator bars. Conducting materials which may lodge between the bars, in or on the surface of the mica insulation, aggravate the condition. Current passing between the bars, through these conducting paths, renders the particles incandescent. Fine carbon which is ground from the brushes by the normal operation of the machine, or particles of copper from a newly-turned commutator, are the most prolific producers of this difficulty. Secondary sources are the oil, paraffin and commutator compounds which are used sometimes. Particles of conducting material may lodge in them. Furthermore, oil may carbonize on the mica segments. This forms a conducting path. In cases of trouble where the mica insulation between certain of the segments has been eaten away, it is probable that the difficulty is due to the carbonizing of the oil or of some of the other materials enumerated above.

Undercut commutators, particularly those rotating at low peripheral speeds, are particularly subject to ring fire. The reason is that oils, greases and conducting materials can, due to the undercutting, lodge readily between segments. Hence the commutator slots of slow-speed machines should be cleaned frequently with a stiff brush. This is to prevent the lodgment therein of these semi-conducting materials. High-peripheral-speed commutators will not, ordinarily, require such treatment, because with them the centrifugal force which is developed is usually sufficient to prevent the retention of the dirt in the slots between segments. In machines of certain designs, the voltage between the adjacent segments under the pole tips may of itself be sufficiently great to produce ring fire. A compensated winding provides an effective corrective for this difficulty. Where

the mica segments are thin, ring fire is correspondingly liable to occur. Furthermore, it may be encountered more frequently with slow-speed than with high-speed machines. With a high-peripheral-speed machine, the commutator segments do not remain, for a long enough period, in the zones where the ring fire is developed to permit the formation of the minute arcs.

Flashing is that species of commutator sparking where an arc attains considerable length and finally flashes over viciously between brush-holder studs. Flashing may occur in a normal machine, at the instant when an excessively-high electromotive force is impressed across its terminals. Or it may be due to the cumulative effect of a number of the causes which promote sparking. Flashing is more liable to occur on motors than on generators.

Auto-Transformers

DISCUSSION OF THEIR ACTION AND CONSTRUCTION; HOW AND WHERE USED. BY V. E. JOHNSON

THERE IS no fundamental difference between a two-coil transformer and an auto-transformer, either in principle, design, or schematic connection. For that reason a discussion of the auto type must be based on a description of a two-coil transformer, that is, one having separate primary and secondary windings.

A transformer is a device for transmitting electrical energy from one circuit to another, through the medium of an iron magnetic circuit. It has a rough analogy in the ordinary pulley drive. In the latter, energy is transmitted from the driving pulley to the belt, and from the belt to the driven pulley. In the transformer, the energy is transferred from the primary coil to the iron circuit and from the iron circuit to the secondary coil. Disregarding mechanical limitations, we can arrange in tabular form the comparison shown in Fig. 1.

Belt Set	Transformer
Driver	Primary coil
Driven	Secondary coil
Belt	Iron magnetic circuit
Rates of speeds	Ratio of transformation
Speed of driver	Primary voltage applied
Diameter of driver	Turns of wire in primary coil
Speed of driven	Voltage generated in secondary coil
Diameter of driven	Turns of wire in secondary coil
Energy changed into belt heat	Iron loss
Energy changed into pulley heat	Copper loss
Per cent slip based on driven speed	Per cent regulation = (No load voltage—Full load voltage)÷Full load voltage

Let us now consider how energy is transmitted from the primary coil to the iron circuit. In Fig. 2 is shown a schematic diagram of a closed magnetic circuit with primary and secondary coils in place. It is a fundamental principle of electricity that a current passing through a wire wound around a piece of iron magnetizes the latter, or, as it is more technically expressed, sets up in the iron a magnetic flux (flow). In order that the action of this flux may be understood, it will be necessary to accept without proof the statement that the flux strength in the magnetic circuit varies with the current strength and with the number of turns in the magnetizing coil. Expressed technically, the magnetic flux varies with the ampere turns.

With a given primary coil and a constant applied voltage, the ampere turns and hence the magnetic strength would be constant. This, then, is analogous to the relation between the driving pulley and the belt speed in the mechanical analogy above.

Going now to the secondary coil, we must accept as true, first, that an alternating magnetic flux cutting a coil of wire sets up in it an alternating voltage; second, that this voltage is proportional to the flux strength and to the number of turns of wire in the coil. It is also proportional to the frequency of the primary circuit; but as we are assuming this to be constant, we may disregard it in our discussion. Therefore with the primary coil maintaining a flux of fixed strength and frequency, we find generated in the secondary coil an electromotive force of equal frequency and of a voltage proportional to the number of turns. This, then, is the analogy between the belt and the driven pulley.

We can also see that just as the speed ratio of the pulleys is proportional to diameter of driver ÷ diameter of driven so the ratio of voltage transformation is primary turns of wire ÷ secondary turns of wire.

ANALYSIS OF TRANSFORMER ACTION

HAVING THUS OUTLINED the principle of operation of the transformer, let us analyze in more detail the various relations of the component parts, by means of vectors. As this is at the best merely an outline of the subject, let us assume a transformer having no iron or copper losses.

First let it be assumed that the secondary coil is open circuited. Then the primary voltage applied passes current through the coils against the opposition of two forces—(a) the resistance and (b) the choke coil effect. This being an ideal transformer with no copper losses, the resistance is zero and the voltage which is applied is entirely expended in overcoming the choke coil effect. This choke effect is due to the fact that the flux which is set up by the primary coil cuts or links with the turns of the same coil and induces in it a voltage which is exactly opposite in phase. The strength of this counter electromotive force depends on the flux strength, which in turn depends on the current flowing.

In Fig. 4 we have a curve A showing the growth, decay and renewal of the magnetizing current in the primary coil. The curve B shows the counter electromotive force which this current sets up in the primary coil, and the curve C the voltage required to overcome the electromotive force. The counter electromotive force is

not in phase with the magnetizing current, but is 90 deg. behind it, due to the fact that the rate of change of flux is greatest when the magnetizing current is crossing the zero line, while at the maximum and minimum points of current the line is horizontal for an instant, indicating no change at these points. In Fig. 3 these relations are shown vectorially. O-MC is the magnetizing current, O-C.E.M.F. 90 deg. behind it is the C. E. M. F., while 90 deg. ahead of O-MC is O-P.L.V., the primary line voltage required to overcome the counter E.M.F. In a transformer very little current is needed to magnetize the core so that only a small O-S.V. will flow. This would set up a flux in the magnetic circuit which would require a primary current O-PC to neutralize. The primary coil would thus have flowing in it two currents—O-MC, which induces the C.E.M.F., and O-PC, which flows to balance the demagnetizing effect of O-S.C. Naturally two such currents could not really exist separately, but would combine to form a resultant current O-PLC which would be the actual current taken from the supply lines. Or, stating this in a slightly different way, the line current O-PLC would in the transformer be divided into two components, one of which (O-PC) would be the power

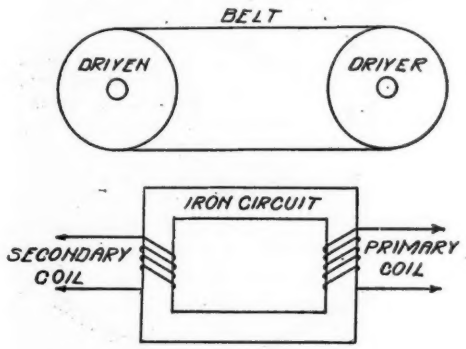


FIG. 1

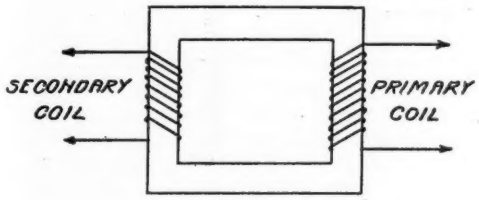


FIG. 2

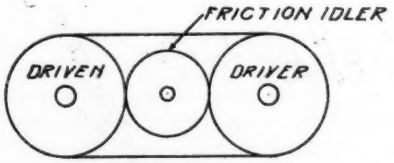


FIG 7

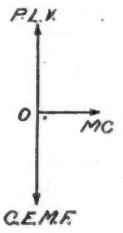
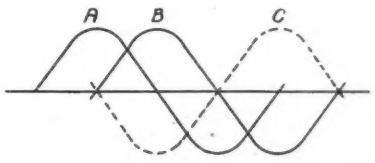


FIG. 3



CURVE A = MAGNETIZING CURRENT
" B = INDUCED COUNTER E.M.F.
" C = LINE VOLTAGE TO OVERCOME C.E.M.F.

FIG. 4

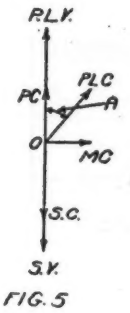


FIG. 5

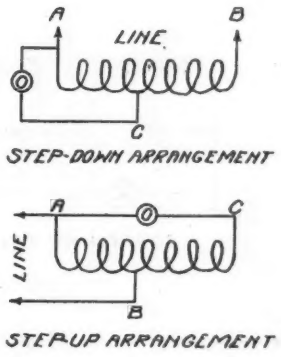


FIG. 6

FIG. 1. ILLUSTRATING MECHANICAL ANALOGY OF TRANSFORMER. FIG. 2. SCHEMATIC DIAGRAM OF CLOSED MAGNETIC CIRCUIT WITH PRIMARY AND SECONDARY COILS IN PLACE. FIG. 3. VECTOR DIAGRAM OF FIG 4. FIG. 4 (A) GROWTH, DECAY AND RENEWAL OF MAGNETIZING CURRENT; (B) C.E.M.F. CURVE; (C) VOLTAGE REQUIRED TO OVERCOME E.M.F. FIG. 5. VECTOR DIAGRAM AS FIG. 3, BUT WITH O-SV SUBSTITUTED FOR C.E.M.F. FIG. 6. SCHEMATIC DIAGRAM OF AUTO-TRANSFORMER. FIG. 7. ELABORATION OF THE BELT AND PULLEY ANALOGY

difference between the impressed and the induced voltages suffice to reach a balance.

The magnetizing current O-MC induces a similar voltage in the secondary coil so that we can also think of O-C.E.M.F. as representing the voltage induced in the secondary coil of the transformer. We therefore construct in Fig. 5 a new diagram exactly like Fig. 3 except that we omit the primary C. E. M. F. and substitute for it the secondary voltage O-S.V. This secondary voltage is in exact opposition to the primary voltage. If the secondary coil is closed through a non-inductive resistance, a load current O-S.C. in phase with component, while the other (O-MC) would be the magnetizing current.

It is not necessary in an article of this nature to analyze this in greater detail, for it is perfectly obvious that increasing O-S.C. would increase O-PC, decrease the angle A and hence increase the power taken from the line. It can be shown too that for all load conditions the current O-MC remains practically constant. It should be particularly borne in mind that the secondary and primary currents flow in opposite directions, as this is a point of importance in the consideration of the auto-transformer.

Having thus in a brief way discussed the electromagnetic principles which govern the action of a two-coil transformer, we can logically go on and apply these to the explanation of the operation of the auto-transformer.

In Fig. 6 is shown a schematic sketch showing this. A B are the line wires and load is taken off between A and C. The coils C D supply some energy electrically and also assist coils A C to supply energy magnetically.

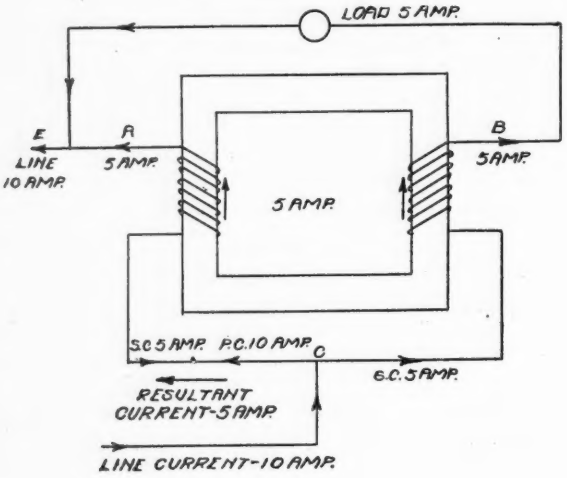


FIG. 9

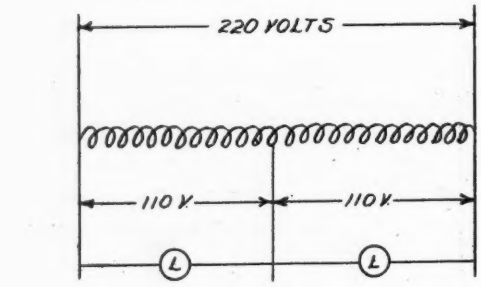
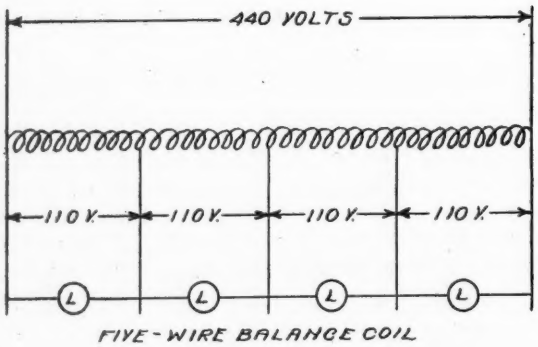


FIG. 10



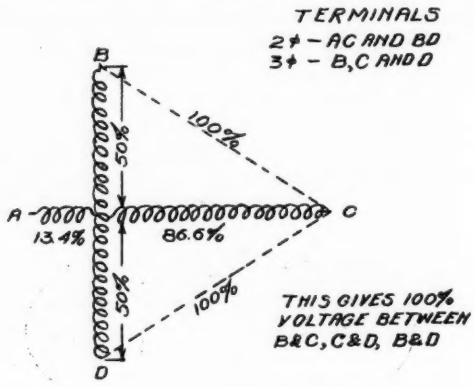


FIG. 12

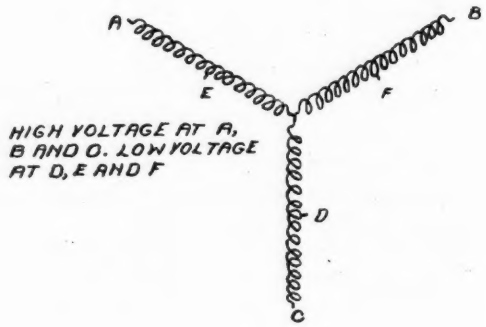


FIG. 13

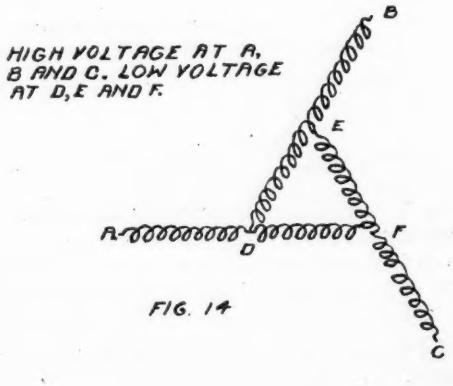


FIG. 14

FIG. 8. AUTO-TRANSFORMER COILS AND CLOSED MAGNETIC CIRCUIT. FIG. 9. AUTO-TRANSFORMER AS A THREE-WIRE BALANCE COIL. FIG. 10. FIVE-WIRE BALANCE COIL. FIG. 12. AUTO-TRANSFORMER USED FOR TWO- TO THREE-PHASE TRANSFORMATION. FIG. 13. SCHEME OF CONNECTIONS USED FOR 6600-13,200-V. MOTOR SERVICE. FIG. 14. SCHEME OF CONNECTIONS ELIMINATING DISADVANTAGES OF THAT SHOWN IN FIG. 13

In an auto-transformer all of the energy is not transmitted to the secondary through the medium of iron, but part of it goes directly through the copper circuit.

Going back to our belt and pulley analogy, we have a scheme as in Fig. 7, which is the same pulley and belt as was previously discussed, with a friction idler

added. Energy is no longer transmitted by the belt alone, but also by the pulley to pulley contact through the idler, thus carrying out and completing the analogy.

By arranging the coils in Fig. 8 as they are in Fig. 2 we at once see that an auto-transformer is nothing more nor less than an ordinary two-coil transformer with an electrical connection between the primary and secondary. If the line be connected to A B and load taken off between A C or B C, the transformer will "step down," whereas if the line be connected between A C or B C and load between A B, it will "step up." If the coil A C equalled the coil B C in number of turns, the voltage in each of these coils would be equal and the ratio of voltage between A B and either A C or B C would be 2.

Assume that the line is connected to A C, and that load is taken off at A B. Under any load conditions with a 2:1 ratio of voltage, the current ratio would be 1:2, and there would be twice as much current flowing in the circuit A C as in the circuit A B. Assume that the circuit A B carries 5 amp. and A C 10 amp., and let us analyze the current flow in the various parts of the transformer. Coil B C would carry all of the higher voltage current or 5 amp. The line leads E and D would carry 10 amp. The coil A C would carry 5 amp. secondary and 10 amp. primary current; but as these currents at any instant flow in opposite directions, the nil current flowing would be 10-5 or 5 amp. The current, however, would flow in a direction opposite that indicated by the arrows on the coil B C. If current were supplied at A B and taken off at E D, the current distribution would be the same. From this we can readily see that there is a considerable saving of copper, as the coil A C, if designed for 5 amp., could actually supply 5 amp. primary and 10 amp. secondary, or vice versa, as the case might be. In other words, a 5-amp. coil would actually be doing the work of a 5-amp. and a 10-amp. coil. It follows also that the copper losses would be greatly reduced, as the auto-transformer coil A C would have lost in it only energy based on a 5-amp. current flow.

In an auto-transformer having a ratio of 2:1, the copper would be of the same cross section throughout, as is evidenced by the example above. If the ratio however, were different than 2:1, the size of copper would be varied. The copper in the high voltage coil would be designed to carry its normal current, while the portion of the winding serving for both voltages would be heavy enough to carry the larger current minus the smaller current. The saving in material increases as the ratio of transformation approaches 1:1 and decreases as the ratio changes from this.

From the foregoing we can readily see that for the more desirable ratios there is obtained a saving of both first cost and operating cost by using an auto-transformer instead of a two-coil transformer. On the other hand, there is an electrical connection between the primary and secondary so that in many cases where such connection would be hazardous the cheaper type would be impractical.

Utility of Auto-Transformers

Auto-transformers are usually used for the following purposes:

1. Balance coil for lighting at 110 v. from 220- or 440-v. mains.

2. Transforming from 2- to 3-phase.

3. Connecting 6600-v. motors to 13,200-v. lines, or similar applications where even the lower voltage is so high that the metallic connection previously referred to introduces no additional hazard.

4. Starting compensators for synchronous and induction motors.

5. Providing lower voltage for moving picture arcs. This is merely a special application of (1) above and needs no discussion.

The various applications listed above will be treated in order below.

1. Balance coil for lighting at 110 v. from 220-v. main.

This is a common application in industrial establishments where power is distributed at 220 v. but where the convenience of 110-v. lights is desired. The connection is very simple and is shown in Fig. 9. Occasionally a balance coil for providing 110 v. from 440 or 550 v. is supplied and used for the same purpose.

FIG. 11. EXTERNAL VIEW OF TYPICAL BALANCE COIL

(See Fig. 10.) These types are commercially built as a modified distribution transformer, and for outdoor service closely resemble an ordinary transformer. In Fig. 11 is shown the external view of such a balance coil.

These coils are made in standard sizes of from 1 to 15 kw.

Transformation from Two- to Three-Phase

The method of doing this is shown in Fig. 12. The sketch has indicated on it the various voltages obtained and the method is too well known to require further discussion.

Auto Transformers for Connecting 6600-v. Motors to 13,200-v. Lines

Figure 13 shows one way of doing this. This has the disadvantage that it would be possible with a small load unbalance to obtain large voltage unbalances due to what is sometimes called a floating neutral. In Fig. 14 is shown a better way—free from the difficulty. Such applications as the foregoing would, however, be special problems and the manufacturer would in every case rule as to the advisability of such an arrangement.

Starting Compensators for A. C. Motors

This is by far the most common application of auto-transformers and as such requires a more extended discussion. The purpose of an auto-transformer on such applications is two-fold: First, to provide a lower starting voltage at the motor terminals and so to reduce the starting current taken by the motor; second, to supply this reduced starting current from the low side of the auto-transformer and so still further reduce the current taken from the line. In this connection it may be said that a so-called "resistance starter" performs the first function above but does not perform the second, as in this type the starting current taken by the motor at the reduced voltage must be supplied by the line without the assistance of a medium of transformation.

A commercial starting compensator is "self contained" or "separate oil switch type," depending on the size of voltage of the installation. For high voltage and large motors, the separate oil switch is used, and the compensator itself is mounted alone in a tank. In the self-contained type the switching mechanism is contained in the same compartment as the transformer coils.

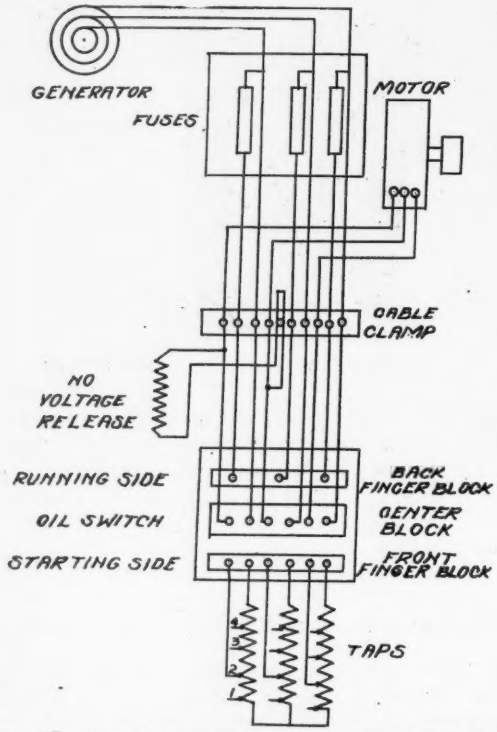


FIG. 15. AUTO-TRANSFORMER CONNECTIONS FOR MOTOR STARTING SERVICE

In either case the switching mechanism performs a two-fold function: First, in the starting position the switch connects the transformer to the line and to the motor and at the same time cuts out any protective devices such as fuses or relays; second, in the running position, it disconnects the transformers and impresses line voltage on the motor, passing the current through the protective devices which may be used.

In the larger installations using separate oil switches, it is sometimes necessary to introduce an intermediate step between the "starting" and "running," especially if the motor in question is a synchronous motor. This step does, however, not introduce anything new into the problem beyond slightly complicating the switching mechanism.

In Fig. 15 is shown typical connections of an auto-transformer for motor starting. When contact is made by the brass fingers between the center block and the front block, the motor receives current from the generator through the taps on the compensator coils. It will be noted that during starting the fuses are not in circuit, thus preventing their blowing from the starting current. The no-voltage release trips the latch on the starting handle and throws the center block to the "off" position if for any reason the supply circuit should be interrupted. The taps marked 1-2-3-4 are provided so that the voltage applied can be varied to suit the conditions under which the motor must start.

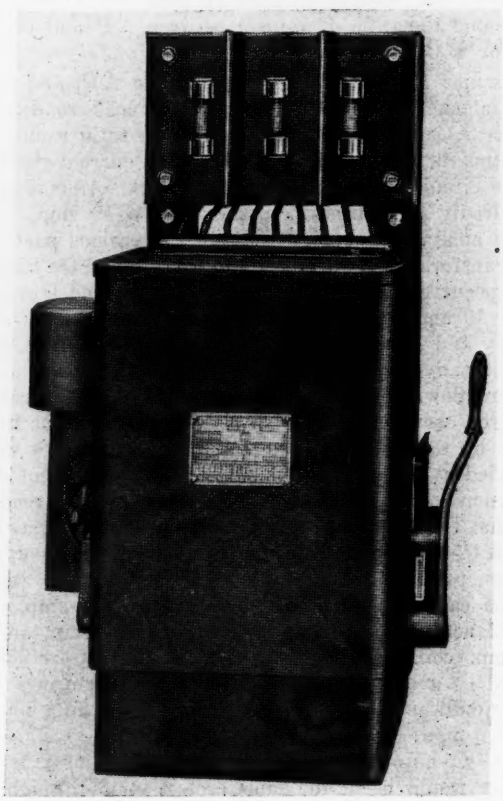


FIG. 16. TYPICAL STANDARD AUTO-TRANSFORMER

In Fig. 16 is shown the external views of a standard auto starter, while in Fig. 17 is shown its appearance with covers removed.

An examination of the above will reveal the following points in common:

1. Contacts all oil immersed.
2. So arranged that starter must be put into starting position before it can be thrown into the running position.
3. Handle arranged so that it cannot be left in the starting position, thus preventing the burning out of the auto-transformer coils by accidentally leaving the motor running on the "taps."

4. Starting connection is made ahead of the protective devices.

5. Arrangements are made for changing taps.

In conclusion, it may be said that every manufacturer is anxious to have his apparatus give good service and is more than willing to supply instruction books covering the installation and care of any of his devices. It would be advisable for operating men to secure from the maker instruction books covering the auto

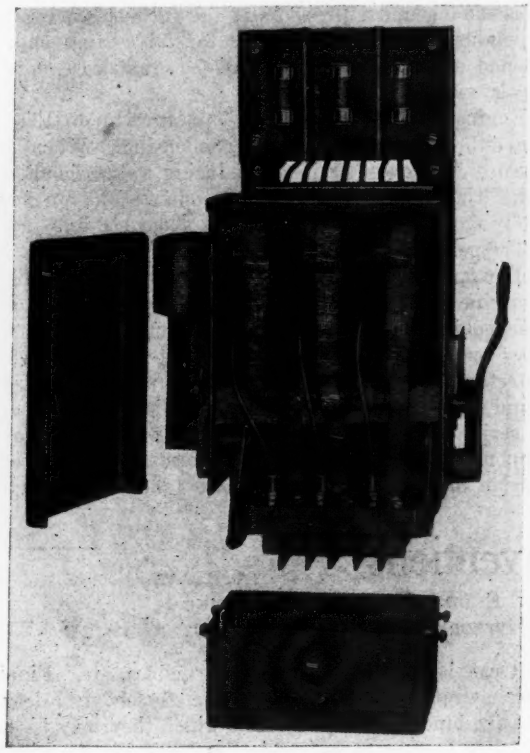


FIG. 17. INTERNAL VIEWS OF AUTO-TRANSFORMER SHOWN IN FIG. 16

starter in their particular plant, and, by becoming familiar with their construction and operation, be prepared for any case of trouble which may arise.

Small Generating Sets for Marine Service

RECENT application of alternating-current propulsion equipment to the "Eclipse," the first of 12 ships to be similarly equipped by the U. S. Shipping Board, has called attention to another use for the small direct-current steam-engine driven generating set aboard ship.

Hitherto the marine application of these sets has been more or less confined to lighting purposes, but on these vessels they have been applied to supply energy for several different purposes. Two 35-kw. sets of this type have been installed on the "Eclipse" to furnish field excitation current to the alternator, besides which they furnish 125-v. d.c. power to operate contactors on the control board, and to run the blower motor.

The complete set consists of a single cylinder steam engine direct connected to a direct-current generator. The cylinder and stroke of the engines vary from 3½ in.

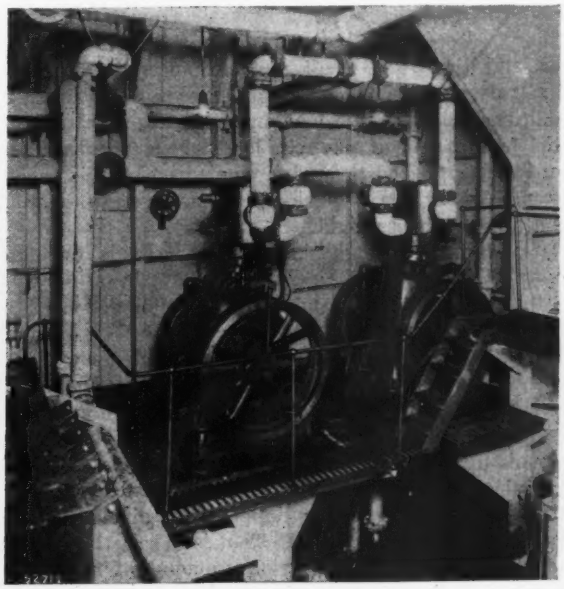


FIG. 1. STEAM-ENGINE DRIVEN GENERATING SETS, S. S. ECLIPSE

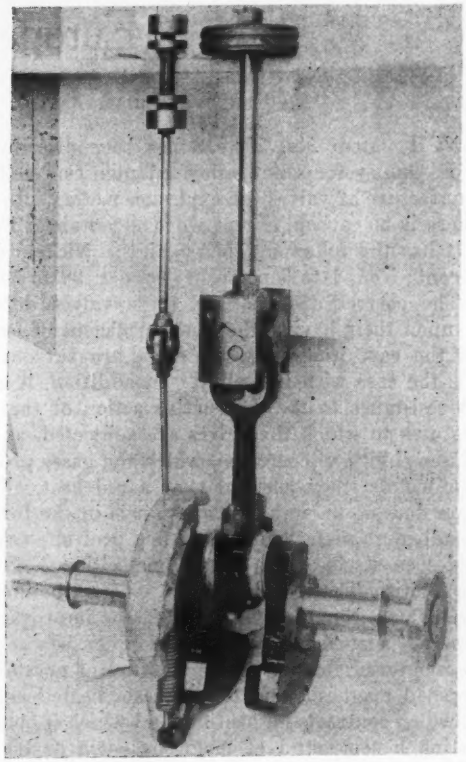


FIG. 2. ASSEMBLY OF RELATING AND RECIPROCATING ELEMENTS OF ENCLOSED TYPE MARINE ENGINES

diameter by a 3 in. stroke for the 2½-kw. size to 12 in. by 11 in. for the 60-kw. size. The engines are con-

structed with a view to attaining the utmost possible in the way of simplicity and ruggedness. Only one valve is used, and a short stroke has been adopted. Operation of the valve and piston is clearly shown by the illustration. The cylinders are cast separate from the column of hard, close grained cast iron, and the ports being short and direct give small clearance space. Automatic relief valves, to relieve water under ordinary operating conditions, and separate hand-operated drain valves are fitted to each end of the cylinder. The steam distribution is accomplished through a single cast-iron balanced piston valve, driven either by an eccentric strap, or pin, from the governor weight.

Governing is accomplished by two methods, depending upon the size of the engine. The 3½ by 3, the 4½ by 4, the 11 by 8 and the 12 by 11-in. cylinder engines are equipped with a flywheel type automatic governor, while the other sizes, from 5 by 4½ in. to 9 by 7 in., have an enclosed type which is inside of the column. In the latter, the piston valve is connected to the governor by an eccentric strap. The strength of the valve stroke depends upon the distance of the center of the eccentric from the center of the shaft, and therefore the amount of steam admitted to the cylinder varies directly as the distance between the centers. That is to say, the shorter the valve stroke the smaller the amount of steam admitted. If the speed reaches a dangerous point, the throwing out of the governor makes the valve stroke so short that no steam is admitted to the cylinder.

The lubrication system also differs with the capacity of the engine. Those in the range from 2½ to 5 kw. employ a gravity system, the oil being contained in a conveniently located tank, and supplied to the various bearings by a number of sight feed tubes. The other sizes are equipped with a forced lubrication system, which functions as follows: The bottom of the column, or crank-case forms an oil tank of large capacity and radiating surface. A small single-acting plunger pump driven by an eccentric which is bolted to the crank shaft forces the oil, under pressure, to the various bearings of the engine. From the bearings the oil escapes and is collected again in the bottom of the crank case, where it cools, and is used over again.

Engines can be operated on pressures up to 125 lb. gage either condensing or noncondensing. When the pressure is above 125 lb., a reducing valve should be used. These engines will operate successfully on moderately superheated steam as used aboard ship.

The generators are especially designed as regards insulation and compactness to meet the severe conditions of marine service. All parts which would be seriously damaged by corrosion due to the action of salt air are either made of corrosion-resisting material, or given a protective treatment. The generators are regularly wound for either 110, 125 or intermediate voltages, and the series windings on the field spools will allow of over compounding up to 5 per cent of normal, by means of a German silver shunt connected across the field terminals.

European Inventions

NEW ALLOY FOR INTERNAL COMBUSTION ENGINE VALVES, GAS TURBINE AND FIRELESS BOILER AMONG RECENT DEVELOPMENTS. BY J. H. BLAKEY

FRENCH patent No. 500,398 has been awarded to W. E. Oakley for a new alloy, adapted especially to manufacture of valves for explosion motors. In this alloy there is no carbon, except what is contained in the iron. It has the following composition: Nickel, about 67 per cent; iron, 1 to 5 per cent; copper, 28 to 32 per cent. The correct operation of these valves depends largely upon their having the same coefficient of expansion as the cast iron by which they are surrounded, which is the case with this alloy. In addition, it offers a great resistance to the destructive action of the high temperatures to which the valves are subjected, as well as an insensibility to corrosion, which the gases produce on other metals when brought near a red heat. When oxidation does occur with this alloy, it is in the form of a thin adherent scale which does not peel off, as with the oxides on steels of the usual composition.

The British Thomson-Houston Co. has obtained an English patent, No. 142,741, class 22, for improvements in refractory materials. The invention consists of a refractory material composed of a mixture of crystallized and crushed magnesia and of magnesia heated and recooled, which contracts on heating, and which is obtained by heating a compound of magnesia, such as the carbonate or hydrate of magnesium, to about 600 deg. C. A binder is used, such as the sulphate or chloride of magnesium, or ferrous sulphate, in addition to this mixture. The compound thus obtained, after being moistened and compressed, makes a good lining for furnaces, or it can be molded into bricks, crucibles, etc. Finally these manufactured articles are heated slowly, to decompose the binder employed; after which they may be subjected to temperatures as high as 1900 deg. C. without injury.

AN INTERNAL COMBUSTION TURBO-MOTOR

MONS. H. S. COLES has taken out French patent No. 489,315 for an internal combustion turbo-motor. In the case A of the motor (Fig. 1) turns the wheel B, into the interior of which air is drawn through holes C in the case, and reaching the interior of the wheel by the holes T (Fig. 2). Vanes E are of such form that the air is drawn toward the interior periphery of the wheel. On the outside of this are buckets F which receive the impulse of the exploding gases in the combustion chambers D, D. In these chambers the combustible is admitted through valves I, I, and ignited by spark plug J. The gas escapes, after acting upon the wheel, through exhaust passages G, G, which are a prolongation, of smaller diameter, of the combustion chambers D, D.

PRODUCTION OF STEAM BY ELECTRICITY; THE REVEL FIRELESS BOILER

THE FIRELESS steam boiler, heated electrically, is coming into use in countries which, like Switzerland, have water power in abundance, but very little coal. The production of heat almost instantaneously, the small heat losses during periods of stoppage, the ease of operation

and regulation, together with the freedom from dust and ash which accompany the use of coal, have made this method of steam production so popular in Switzerland that there are now more than 300 of these boilers in operation in that small country. It has been found that from 3000 to 4000 kw.-hr. of energy will produce the same amount of steam as a ton of coal, so that it is a simple matter to compare the cost of generating steam by the two methods. This electrical method is in use not only for the production of steam, but also for heating water for the warming of living rooms and workshops, and for the heating of liquids other than water, in industries of various kinds.

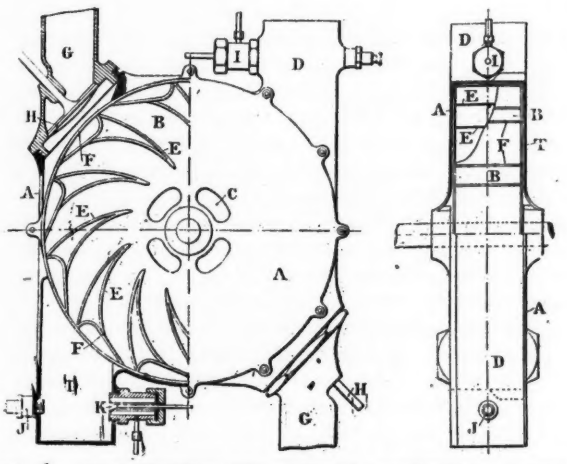


FIG. 1. CROSS-SECTION OF INTERNAL COMBUSTION TURBO-MOTOR

FIG. 2. SECTION OF INTERNAL COMBUSTION TURBO-MOTOR PARALLEL TO SHAFT

The Revel electrically heated boiler is made by the Society Escher Wyss of Zurich, and by the Ateliers de Construction d'Oerlikon. Figure 3 shows in diagram the general arrangement. The feed water is pumped in at a; the steam pipe b carries the steam to the valve v; at c is shown one of the two electrodes which pass through the steam-tight insulation fittings in the top of the boiler. Current used is alternating, monophase or triphase; direct current cannot be employed because it decomposes the water. An ammeter indicates the intensity of the current passing at any moment through the water. Valve e is for the cleaning out of deposits, and valve f regulates automatically the circulation of the water, as will be explained. The feed pump is driven by a small motor (Fig. 4).

The boiler being empty, the current is turned on, but the circuit is then open; it is only when the water rises to the level of the points of the electrodes that the current begins to pass and a small amount of steam is generated. The intensity of the current and that of vaporization increase as the water covers more and more of the electrodes, and the boiler is under pressure at the end of about 10 min. As soon as the working pressure is exceeded, valve f, regulated for this pressure, opens automatically and allows the passage of a certain amount of water into the tank (Fig. 4). In this way, the water level and consequently the amount of vaporization, is varied according to the quantity of steam required. If the steam is discharged regularly, the pressure is maintained; if the load increases and the pressure tends to diminish, the feed water comes in faster, a larger quantity of current passes and vaporization is increased. But before the steam can reach a pressure much higher than normal, valve f comes into play, acting as a safety valve. If valve v is closed, the steam generated drives the water through f until only the points of the electrodes are covered, and just enough steam is generated to compensate for the heat losses. Consequently the boiler requires no attention beyond the starting and stopping of the current.

A boiler about 8 ft. in height and 2 ft. outside diameter, fed by a 550-v. current, gives per hour about 1200 lb. of steam at a pressure of 33 lb. per sq. in., or a vaporization of about 2.9 lb. of water per kilowatt-hour furnished to the boiler. The percentage of moisture in the steam rarely exceeds 3 per cent, except when the load varies quite considerably.

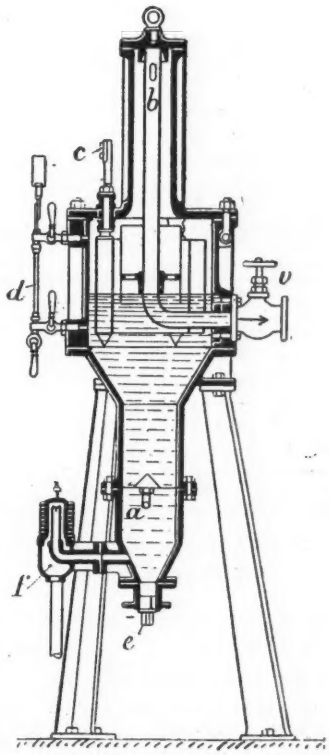


FIG. 3. GENERAL SCHEME OF ELECTRICALLY HEATED BOILER

The following figures give the results of a test of a Revel boiler conducted by the Swiss Society of Steam Boiler Owners:

Duration of test	2½ hr.
Voltage, average	219 v.
Current, average	384 amp.
Power, average from meter	367 kw.-hr.
Power, average per hour	146 kw.-hr.
Mean effective pressure in boiler	94.3 lb.
Average temperature of feed water	10 deg. C.
Average temperature of discharge water	14 deg. C.
Heat of vaporization per lb. of steam	296.6 calories
Total amount of steam generated	1014 lb.
Steam generated per hour	405 lb.

Steam per kilowatt-hour..... 2.76 lb.
Water at 0 deg. into steam at 100 deg. C. per kw.-hr..... 2.8 lb.
Total amount of water in steam..... 29.7 lb.
Percentage of moisture.....2.93

Total amount of feed water was 1697 lb.; of this 683 lb. was discharged. Consequently there was transformed into steam 1014 lb. of water, and 683 lb. was heated from 10 to 14 deg. C. Therefore for the efficiency of the boiler we have:

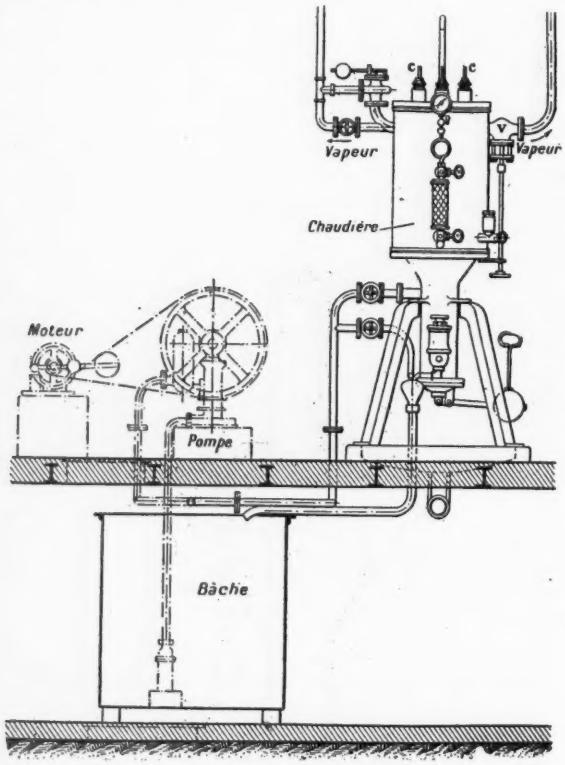


FIG. 4. ELECTRICALLY HEATED BOILER WITH FEED PUMP AND DRIVING MOTOR

Heat utilized for the production of steam, $1014 \times 296-6$.....300,748 calories
Heat added to discharge water, 310.5 kg. $\times 4$ ..... 1,242 calories
Total effective heat produced.....301,990 calories
Total theoretic heat produced by the electricity, 367 kw.-hr. $\times$ 860.....315,620 calories
Efficiency of vaporization..... 95.3 per cent
Reheating of discharge water..... 0.4 per cent
Total efficiency ..... 95.7 per cent

As this boiler was designed for 200 kw. and the average used in the test was only 146.7, it is believed that these figures could be exceeded.

The foregoing is condensed from an article by Mons. Constam-Gull in Le Genie Civil for Sept. 4, 1920.

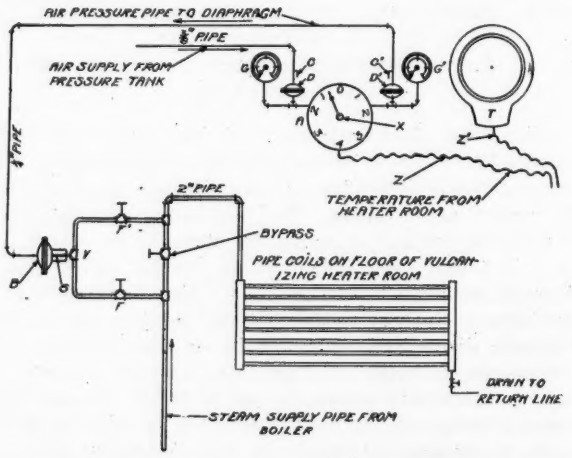
THE OWATONNA city council, Owatonna, Minn., has passed a resolution calling for a special election to vote for a $475,000 bond issue for the erection of a municipal lighting, power, heat, and gas plant over the mayor's veto.

Temperature Regulation for Vulcanizers

BY R. A. CULTRA

ONE of the most important members of a rubber vulcanizer is the steam jacketed tank which consists of inner and outer shells, both riveted to the flange ring at the door. This packet must be stayed the same as the fire box for a locomotive boiler to prevent the inner shell from collapsing. Then, if the return pipe is connected to a vacuum return pipe system, the tendency toward collapse is increased. Pitting may occur between these two shells, especially on the bottom, and the extent to which it may go before being discovered can only be conjectured. I have seen some of these tanks where the plate riveted to the flange door ring was worn away more than 1/16 in. on the inside by erosion, and appeared to be crystallizing. I think regular inspections would serve to keep these tanks in better repair and many of the disastrous explosions would thereby be avoided and many lives saved.

In the accompanying illustration is shown a general layout of the piping and instruments of a vulcanizing heater room. The steam supply comes from the boiler passes through valve F, regulating valve V and stop-valve F^1 to the heating coil on the floor of the room. B is the diaphragm on the regulator and S the spring on the valve stem. T-is a recording thermometer. A is the key to adjustment, which is set for any desired temperature as the pointer indicates and the recording


AIR PRESSURE PIPE TO DIAPHRAGM
AIR SUPPLY FROM PRESSURE TANK
4" PIPE
2" PIPE
TEMPERATURE FROM HEATER ROOM
BYPASS
PIPE COILS ON FLOOR OF VULCANIZING HEATER ROOM
DRAIN TO RETURN LINE
STEAM SUPPLY PIPE FROM BOILER

GENERAL SCHEME OF PIPING FOR VULCANIZING ROOM

chart shows. The tubes, Z, Z^1, are the expansion tubes running into the heater room. By adjusting the pointer, by inserting a key at X on the instrument, A, the valve on the back will operate for any temperature for which it is set. G, G^1 are low-pressure air gages. A pressure is maintained in a supply tank by an air pump. The air at low pressure enters the 3/8-in. pipe from the tank, passes through the stop-cock, C, and through D, and indicates the amount of tank pressure at G. The pointer on A is set to maintain a given temperature and this temperature not yet reached the valve on the back is held closed so no air pressure can pass through D^1 and C^1 to the diaphragm B, which pressure is indicated on

the gage G^1. But when the heat in the room reaches the temperature desired, as the chart shows, the expansion in the tube Z causes the valve on the back of A to open and put an air pressure on the back of diaphragm B, which shuts off the steam close enough to keep the temperature in the room up to or above 242 deg. F. as indicated by the chart. Instrument A is then in active operation by expansion and contraction in tube Z, and this keeps the air pressure on B at an equilibrium to admit just what steam may be required.

Too much heat will spoil the goods and not enough will not cure or vulcanize them. The principal troubles in operation are that the diaphragm may give out, the pipes and valves may become choked with dust and require cleaning, or the air pump may fail to deliver the proper amount of air from usual air pump troubles; the steam valves may become worn and leak, thus giving a higher temperature than desired, or cause wide variation in regulation; the spring on the steam regulating valve stem may become broken or weakened, which, however, seldom occurs, and interfere with maintaining a steady temperature.

The vulcanizing presses all have steam gages, but when they are heated up will maintain an even heat that will vulcanize to the desired degree of hardness or temper of the stock.

Lubrication of Compressed Air Machinery

DIFFICULTIES ENCOUNTERED IN THE LUBRICATION OF AIR COMPRESSORS; REMOVAL OF CARBON; OIL SPECIFICATIONS

DIFFICULTIES in the way of providing proper lubrication for compressed-air machinery are largely due to the extreme high and low temperatures to which the lubricant is exposed, and, in the case of the compressor, to the fact that oil when in contact with heated air may deteriorate and become a source of trouble unless proper precautions are taken. The lubrication of compression and expansion machinery presents radically different problems and these shall be considered independently.

Air compressors as built today may be grouped under the following heads:

(a) Blowers.
(b) Rotary compressors.
(c) Blowing engines.
(d) Single-stage reciprocating compressors.
(e) Multiple-stage or compound reciprocating compressors.

The lubrication of blowers presents no particular difficulties and depends upon the type of bearing or its accessibility. A good grade of light machine oil or a high-grade grease is usually found satisfactory.

Rotary compressors usually require only a good grade of light machine oil of sufficient body to maintain a satisfactory seal between the moving parts and the housing. Where high pressures are attained, the same conditions exist as in high-pressure piston compressors and will be considered under that head. Rotary compressors are often used with other gases than air and require an oil which will not be affected by these gases. These special cases should be discussed with the lubrication engineer of a reputable company and will not be considered at this time.

In blowing engines, the pressures and temperatures are low and the lubrication of the cylinders may not require a special type of oil, but it is the best policy to use an oil suitable for the high-pressure type of piston compressor.

The lubrication of the external bearings, crossheads and cranks of piston compressors is no different from that of similar classes of steam machinery, the oil being of proper character to withstand the pressures and the tendency toward gumming and deterioration. When, however, as in the case of many vertical and some horizontal units the splash system is used to lubricate the cylinder, the characteristics of the oil are governed by the requisites of piston lubrication. If properly designed so as to get the right amount of oil to the various points, and in particular neither too much nor too little oil to the cylinder walls, the splash system is ideal, as it requires no attention except the filling of the crank case when necessary. These factors should be considered carefully when this system is contemplated.

Internal Lubrication

IN SELECTING an oil for the internal lubrication of the air compressor, the position and condition of the cylinder, the speed of operation and the weight and fit of the piston must always be considered. Other factors which govern are the degree of compression employed, the temperature developed, the methods used in cooling the cylinder and the manner of applying the oil. In vertical compressors, practically the only pressure on the cylinder walls is that due to the tension of the piston rings, and an oil of sufficient body to maintain a seal about the rings will be found quite adequate to prevent frictional wear. In horizontal compressors, the weight of the piston is carried by the bottom of the cylinder and it is necessary, as a result, to use an oil of sufficient body to prevent metal contact even in the presence of considerable heat. Low-speed compressors and those having heavy or loose-fitting pistons require a heavier oil than those operating at high speeds or those fitted with light or tight-fitting pistons. When pressures and temperatures are high, heavy-viscosity oils must be used as high temperatures reduce the viscosity and allow air to slip back past the piston. For lower pressures and temperatures, lighter grades prove quite successful. It should be accepted as a definite rule that the lowest viscosity oil that will successfully lubricate the cylinder wall and seal the piston rings and valves should be used in the air compressor.

There is some controversy among engineers over the relative merits of low and high flash oils. As usually manufactured, no straight-run oil which has sufficient viscosity to take care of the friction of the piston, has a flash point under 300 deg. F. at atmospheric pressure. To get a flash at this temperature, a flame or spark must be applied. Spontaneous ignition will not take place even under a very much higher temperature. In both

these cases, there must be a critical mixture of vapor and air, the proportions of which have narrow limits. If the compressor is properly operated, the excess of air over oil is so great that it is practically impossible to get an explosive mixture even if a spark were present.

While the parallelism is not strictly perfect, high-flash oils also have high viscosities and what is more to the point, high distillation end points. The cylinder walls are cooled by water jacketing, hence the temperature of the oil layer next to the wall is practically little above that of the wall. The oil layer exposed to the heated air, however, becomes much hotter than the rest of the oil body and a portion of it will vaporize. As oils are composite mixtures, different portions distilling at different temperatures, the lighter products will distill, leaving the heavy ends dissolved in the oil next to the wall. The final result is the building up of a gummy mass which has such a low vapor pressure and high distillation point that it is not taken up by the air as fast as is necessary.

Oil when subjected to heat, especially hot air, gradually decomposes into volatile compounds and carbon. The extent of this decomposition depends on the temperature and length of time the oil is exposed to the heat. This vaporization and the breaking down of the oil are going on simultaneously and if the distillation is slow or the quantity large the oil is subjected to breaking down conditions during a longer period and more carbon is formed. Compounded oils are also contributory to the formation of carbon. The fixed oils and fats used for compounding do not distill when exposed to high temperatures. Instead they decompose and form a gummy and particularly objectionable form of carbon which adheres to the valves and discharge passages.

Carbon Formation

Carbon may be formed in cylinders in a hard mass or it may be produced in the shape of dust and pass out with the air. In the latter case it will probably collect at elbows or on sharp edges and become mixed with dirt taken in by the air and oil vaporized in the cylinder and condensed at these points. If formed in the cylinder, carbon being a poor conductor, may become heated considerably above the temperature of the cylinder walls.

Whether carbon can become sufficiently heated to ignite or not is still a disputed question. Some claim incandescent carbon to be the cause of explosions, but that is doubtful for to have an explosion there must be a critical mixture of oil and air. Hard carbon, however, is always a nuisance and many times it accumulates on the valves and valve seats and is packed firmly into the ends of the cylinders, causing the valves to leak and frequently resulting in the cutting of the valves and scoring of the cylinders.

Cases have been found where carbon collected in the valve passages and bends of piping to such an extent as to restrict the opening through which the compressed air had to pass. When once started, this carbon continues to build up and so narrows the passage that enormous pressures may be produced and eventually cause an explosion back of the obstruction.

It is claimed that carbon may be successfully cleaned from air systems with soap suds. The mixture, containing one part of laundry, or preferably, soft soap, to 12 to 15 parts of water, may be fed into the cylinder through the lubricating system, instead of oil, for several hours. Feed the suds liberally and then blow the mixture of carbon, oil and water out of the system.

Some engineers recommend this treatment weekly, but if correct lubrication is employed cleaning will have to be resorted to only after long periods of operation, if at all. Kerosene or gasoline, should, under no circumstances, be used for purging the cylinder, and when soap suds are used, oil always should be fed to the cylinder for an hour or so before the compressor is shut down. This is to prevent rusting. Regularity in cleaning and blowing out the discharge lines and receivers will greatly diminish the possibility of an explosion, but the best insurance is correct lubrication.

Oil Specifications

The problem, then, which confronts the lubrication engineer is the production of an oil which will not form hard adhering carbon, and still have a sufficiently high viscosity to act as a good lubricant. To meet these conditions and produce an oil with a fairly low distillation end point, it has been found advisable to prepare an oil especially for the purpose and not use any of the ordinary grades found in general machine practice.

The Compressed Air Society has issued the following specifications:

Paraffine Base Oils

	Minimum	Average	Maximum
Gravity, Baume	28-32 deg.	25-30 deg.	25-27 deg.
Flash point, open cup	375-400 deg. F.	400-425 deg. F.	425-500 deg. F.
Fire	425-450 deg. F.	450-475 deg. F.	475-575 deg. F.
Viscosity (Saybolt at 100 deg. F.)	120-180 sec.	230-315 sec.	to 1500 sec.
Color	Yellowish	Reddish	Dark Red to Green
Congealing point (pour test)	20-25 deg. F.	30 deg. F.	35-45 deg. F.

Asphalt Base Oils

	Minimum	Average	Maximum
Gravity, Baume	20-22 deg.	19.8-21 deg.	19.5-20.5 deg.
Flash point, open cup	305-325 deg. F.	315-335 deg. F.	330-375 deg. F.
Fire	360-380 deg. F.	370-400 deg. F.	385-440 deg. F.
Viscosity (Saybolt at 100 deg. F.)	175-225 sec.	275-325 sec.	475-750 sec.
Congealing point (pour test)	0 deg. F.	0 deg. F.	0 deg. F.

It is suggested that those oils within the range expressed by the minimum figures be used for light duty of low pressure and emperatures, while those expressed by maximum figures should be used for high pressures and temperatures.

A suitable air compressor oil should be a straight-run, filtered, pure mineral product flashing above 300 deg. F., and giving a low carbon residue on distillation. The viscosity will depend on the type of compressor and upon operating conditions, but for ordinary service the recommendations given below will be found satisfactory:

Single-stage compressors to 50 lb., splash feed..300 sec.
Single-stage to 50 lb., mechanical lubricator...200 sec.
Single-stage to 110 lb., splash feed.....750 sec.
Two-stage to 50 lb., mechanical lubricator.....200 sec.
Two-stage to 110 lb., mechanical lubricator....300 sec.
Multi-stage to 3000 lb.....750 sec.

The methods adopted for feeding oil to the air compressor cylinders vary in different types and makes of

machines. Ordinarily, however, the oil is introduced into the air intake at the point where it enters the valve chest. Here it is atomized by the inrushing air and carried to the valves and all parts of the cylinder as in the steam engine.

Oil may be fed to the cylinder by means of vacuum cups, but greater economy and satisfaction will be obtained through the use of automatic force-feed lubricators. Force-feed lubricators are not affected by changes in the air pressure and feed the oil in exact conformity with the speed of operation. In order to prevent oil accumulating in the cylinder, lubricators should be shut off just as the compressor is stopped.

We shall not attempt to lay down any fixed rules as to the amount of oil that should be supplied to the air compressor cylinder. This will depend upon the size of the compressor, its speed, and the condition of the piston and cylinder walls. It has been our experience, however, that more trouble is caused by using too much oil than too little. Just enough oil should be used to prevent frictional wear and permit the free and easy operation of all parts. More may lead to trouble.

If upon removal, the discharge valve is greasy, enough oil is being fed to the cylinder. If it is dry, feed a little more.

While we have attempted to give a general idea of the characteristics necessary to a high-class compressor oil and some brief notes on its application, the number of types of compressors is so great and the requirements of the various types so diverse that it is practically impossible to give more than a general idea. Unless thoroughly advised by the manufacturer, it is advisable at the least sign of trouble to consult the engineer of a reputable oil company, who has made a study of the subject.—Reprinted by permission from Lubrication, published by the Texas Co.

The Supply Man in the Ice Industry

IN AN ADDRESS on the subject of the utility of the supply man in the ice industry, A. P. Miller explained the functions of such an organization and the service which it was able to render to purchasers of refrigerating and ice making equipment and supplies. He continues:

"The supply house is a comparatively recent advance in the development of the industry, but it is becoming recognized as a necessary adjunct of the ice and refrigerating trade. It offers a manifold service which the manufacturer will find more valuable as he avails himself of it.

"Briefly, the service that the supply house offers to the ice manufacturer is: first, it furnishes him with capital; second, it stores his materials for him; third, it provides him with qualified buyers and with the facilities for buying most cheaply and satisfactorily; fourth, it insures to him something exceedingly difficult to obtain in these days of labor unrest, and that is prompt delivery of the supplies purchased.

"A supply house stores the goods for you. Its warehouses are centrally located and large enough to carry a complete stock. Everything that may be needed is to be found there; it is a headquarters for everything pertaining to ice manufacturers' supplies, dealing exclusively in accessories, auxiliaries, appliances, equipment, refrigerants, chemicals, specialties and engineers' supplies, incidental to cold storage and ice making.

"Such a supply house has every facility for getting the goods to the ice manufacturer. By efficient trucking and delivery service, goods can be delivered to the manufacturer promptly when he needs them. If the ice manufacturer deals with such a supply house he will not have to wait for materials when they are urgently needed.

"The supply house helps the manufacturer in buying and by careful study of the requirements of the trade, and with an intimate knowledge of the markets, the supply house is enabled to hold a worthy position as a representative establishment in the ice and refrigerating trade and it enjoys the good will, confidence and cooperation of the foremost manufacturers of refrigerating supplies, and through these factors, as well as by its purchasing power, secures in many instances great advantages. With its ample resources the supply house is able to take advantage of all cash discounts; therefore it is in the most advantageous position for giving the best service to its customers at the least cost.

"But the time has long passed when commodities are judged by price only. Quality, today, is the outstanding feature. The successful buyer must not only know the markets and their fluctuations so thoroughly that he may be able to buy the supplies he needs at the lowest possible price; it is even more important that he should be so familiar with the qualities of materials, should understand so thoroughly the differences between various commodities or accessories intended for the same purpose that he can be sure he is buying exactly what he does want, the very best thing suited to his purpose. He must have so wide an outlook over the whole field of production that he needs to devote his whole time to the study of it. He must be a specialist. The iceman, whose chief business is the manufacture of ice, cannot afford the time to become such a specialist. He can serve his purpose better by giving all his attention to the many difficult and delicate problems connected with actual manufacture, at the same time availing himself of the supply man's wide outlook and special knowledge by letting him do the buying.

"Adaptability and stability are the fundamental principles of economy. Such adaptability and stability it is the aim of the supply man to secure for the ice industry. The supply man enables the ice manufacturer to obtain just what supplies he needs in such volume and at such time as he needs them, and serves to make all the materials necessary to his industry easily and economically available."

A Correction

OUR ATTENTION has been directed to the fact that the captions for cuts, Figs. 15 and 18, on pages 11 and 13 respectively of the Jan. 1, 1921, issue are incorrect, inasmuch as the term telpherage is applicable only to overhead conveyor systems in which the source of power and the controlling mechanism is integral with the moving carriage. Since the systems referred to in the photographs have the source of power and the controlling apparatus located on the ground, they should properly have been termed trolley carrier systems.

Flywheel and Governor Accidents

SOME TIME ago, wishing for a change of pasture, I took a leave of absence good for a year and went forth to find new experience and a new view of things in general.

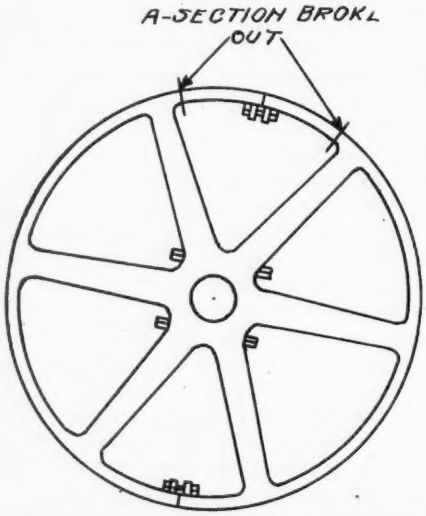


FIG. 1. FLYWHEEL SHOWING LOCATION OF BROKEN SECTION

I was away about 7 mo., and during that time, had more experience at first hand than ever before in 20 yr. of a more or less varied career as a stationary engineer.

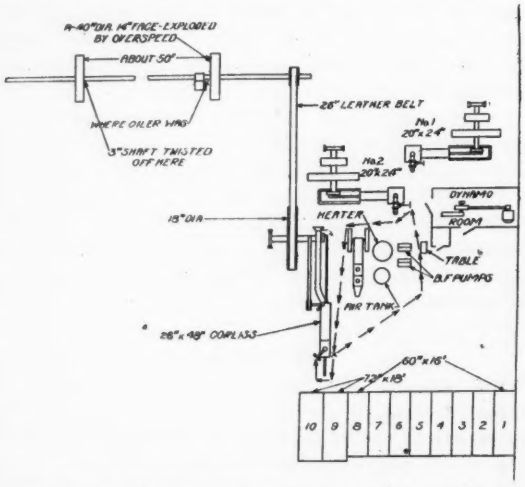


FIG. 2. PLAN OF PLANT WHERE FLYWHEEL BROKE

The first one was the bursting of a flywheel as shown in sketch Fig. 1. As indicated, this wheel was cast in two sections, bolted together as usual with wheels of that type; 80-in. diameter, 26-in. face, 200 r.p.m., and was on engine No. 2, Fig. 2. This engine was belted to a 9-in. edger, and when running would repeatedly be pulled down from full speed to 15 or 20 r.p.m. A timber had just cleared the edger and the engine had picked up to full speed, when there was a report like a 3-in. gun, and the engine room was full of dirt and dust. It was impossible to see just what had happened, or to tell whether it was No. 2 engine or the 26 by 48-in. Corliss that had broken, and to further complicate matters the belt from the Corliss was carried on an idler below and held down by a tightener from above, and drove at right angles through No. 2 engine drive belt. After getting them both stopped, a section of the rim of No. 2 flywheel was found to have broken, as shown in Fig. 1. All bolts in joint were in good condition. The metal showed an old crack about halfway through and halfway across the rim of the wheel. The piece went up through the floor,

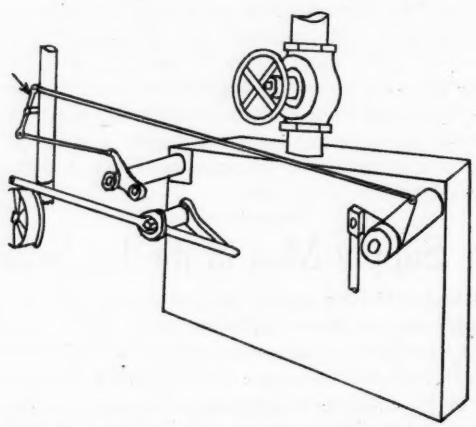


FIG. 3. LOCATION OF BROKEN GOVERNOR PART

cutting and tearing away two 2 by 12-in. timbers and 3-in. plank floor, and about 12 ft. in the air above the floor, falling to one side of hole. Four men could hardly lift the piece.

Welding the piece back in place was tried, but did not prove successful, as when the engine was started up after the weld was completed, the piece came out again before the engine had reached a speed of 50 r.p.m. Fortunately nobody was hurt during the wreck.

The second wreck was caused by the breaking of the governor on Corliss engine, Fig. 2, allowing it to run away. Although no great damage was done to the engine itself, beyond a couple of broken bolts in the frame, which did not show up for about a week afterward, the damage due to excessive speed, bursting pulleys, tearing out and twisting off shafting, tearing up belts, wrecking three sprinkler systems and a few steam pipes amounted to about $3500 to $5000 in 2 min. or less.

To give some idea of the length of time that elapsed from the time I first noticed that the engine was racing, I shall write it down as events occurred. The mill had run 4 hr. and shut down for lunch. During the time the crew was eating, I oiled up and examined as far as possible all engines shown in Fig. 2 and one not shown, 25 min. being the time I had for this. Everything looking O. K., I started up as usual and as soon as everything was moving, took my lunchbox and sat on the corner of the Corliss engine foundation at X and ate lunch. After this agreeable occupation I followed the course of the arrows to the table and disposed of my lunchbox. At this point I got signals to stop No. 2 engine. (Everything was run by whistle signals.)

I went to No. 2 engine and closed the throttle; just as it closed I heard a noise not down on the usual program. I looked up and saw that the Corliss was racing. I had to follow the line of arrows to get to the throttle, and by the time I got there things were going. Pulley marked A let loose just as I started from No. 2 engine, and incidentally it ripped down pipe in two sprinkler systems, a steam line, the floor both above and below it. Strange as it may seem, the oiler was between this pulley and post, at point marked X, reaching around the post and screwing down a hard oil cup. He got out without a scratch although there was only 14 in. between pulley and post and he did not know for about 15 min. that the pulley broke.

As indicated by arrows, I was traveling just about then (used to be able to do 100 yd. in 11½ sec.—think I did it in 10 sec. less than nothing). Finally I arrived and got the throttle shut, expecting to see the flywheel disappear, but it didn't. When things stopped, I found the governor arm broken at point marked by the arrow in Fig. 3. This left the head end steam valve wide open and knockoff cam on crank end was sheared off and there she was, wide open. I could not see until I got around the tail rod what was the matter and the big idea that stuck in my head was, "why is the engine racing so and the governor running?" The governor belt was on, and safety stop properly set and in working order. No sticks or anything were found anywhere near the governor that looked as if they could have done the damage.

Although I have been an engineer some time, I never heard of a case just like this and of all the engineers and other mechanical men who looked at it, none seemed to be able to tell what broke the governor. I would like the opinions of others as to the cause. I don't know and was right there. I heard no unusual noise or behavior of the engine before this; after it broke, there was only one thing to do and I was the doer. I have heard men say before now that they never got scared in such times, but I will tell the world that I was scared good and plenty and expected to get hurt if nothing worse, but still would like to know what broke the governor.

OPERATOR.

Special Double-Acting Deep-Well Pump

ON PAGE 1194 of the Dec. 15 issue, I have noticed N. G. Near's single stroke or single action pump that discharges on both strokes.

I am enclosing a sketch of a deep-well pump which performs the same function in a different way and enables a smaller motor to start and operate the pump.

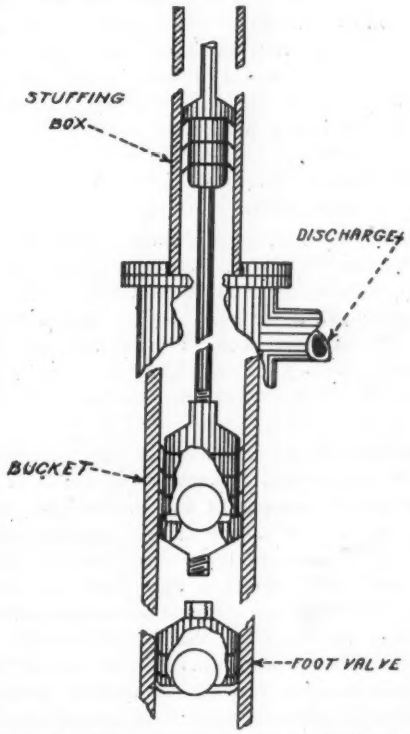
The double-acting deep-well pump is more or less complicated and contains several cup packings, both inside and outside pattern, that do not exactly appeal to the average engineer. If suitable overhead room is available the ordinary stuffing-box may be removed and a brass pipe, flanged at bottom, applied as shown in the sketch.

If a 3¾-in. cylinder is used and a 1-in. pipe for bucket rod, a 3-in. brass pipe is proper size for top plunger.

Area of lower bucket $(3\frac{3}{4})^2 \times 0.7854 = 11$ approx.

Top cylinder should be half of this, or 5½ in. $[(3)^2 \times 0.7854] - [(1\frac{1}{4})^2 \times 0.7854] = 5.84$ (1-in. pipe approx. 1¼ in. outside diameter).

Bucket rod is not deducted from bucket as lower end of bucket is lifting medium.



DEEP-WELL PUMP WITH DOUBLE DISCHARGE EFFECT

On up stroke, approximately half of water enters discharge pipe and half enters upper cylinder. On down stroke, water from upper cylinder is forced out discharge.

On extremely deep wells the upper cylinder or stuffing-box may be made of greater diameter to compensate for weight of rod, crosshead, etc. I have seen deep-well pumps conterbalanced with very heavy weights. It seems a more satisfactory method by balancing with the apparatus described above.

TOM THUMB.

Dangers of Lax Inspection

A FEW WEEKS ago, a horizontal return tubular boiler was taken out of a large paper mill near here. The boiler had been declared unsafe last summer, but had to be kept in service in order to keep the mill running.

When this boiler was taken out, a roller was put under the front end near the second girth seam. The shell

was so thin that it would not hold its own weight and crumbled in about 4 in. I understand that the inspector and owners knew this boiler was defective away at this point.

It would seem to me that when a boiler is in a possibly dangerous condition it should be condemned at once; no chances of explosion should be taken.

This boiler had been run about 6 mo., endangering the lives of employes and property. Is it possible that insurance companies are afraid they will lose their risk if the inspectors are too severe? W. N. L.

Making One Boiler Do the Work of Three

NOT LONG AGO, the writer was called into an industrial power plant to help straighten out some kinks in the operation of the plant. On arriving at the plant, it was found that the mill was shut down more than half the time because the steam pressure could not be maintained. A survey of the plant was made to determine the load on the power plant and whether the load was variable or constant. This survey showed that the load was almost constant, over the entire 24 hr., and that it amounted to approximately 500 hp.

The steam generating equipment consisted of three 250-hp. horizontal return tubular boilers, set in the usual way. Each boiler was served by a set of shaking and dumping grates of good design, and contained 42 sq. ft. of effective area each. Feed water was furnished by an open heater, of about 1000 hp. The water was fed to the boiler by either of two duplex boiler feed pumps.

At the time of our arrival at the plant, all three boilers were in service and coal was being fed to the boilers at the rate of 32 tons per 24 hr.; the fireman was either shoveling in coal or raking it out continuously. One fireman, one ashman and one coal wheeler were kept busy on each shift and then the plant was shut down more than half the time because the steam pressure refused to stay up to a point that would keep the engines running. It was recommended that the boilers be cooled down, one at a time ,and an examination made to find the trouble, which was done. An examination of the furnace was made and everything seemed to be in good shape except a few cracks in the brickwork, and possibly the boiler was set a little too close to the grate; but, of course, this could be remedied only be resetting the boiler, which was out of the question at the time, at least. On reaching the breeching, which was a horizontal run of about 40 ft., a portion at least of our trouble was located. This was piled more than two-thirds full of soot and ashes, which impaired the draft to such an extent that the proper rate of combustion could not be secured to carry the load. At this juncture, all the boilers were cooled down and the breeching was cleaned out from the boiler clear through to the stack. After that, we were able to carry the load on two boilers without crowding them in the least. We then opened the idle boiler for an internal examination. We found that a scale formation 1/16 to 3/16 in. thick had accumulated on the heating surfaces. All three boilers were scaled, after which a good compound was used to prevent a further formation.

After giving the settings a good coat of plastic covering to stop the air leaks and making a few minor repairs to the grates, we decided that we could possibly carry the load on one boiler. The number two and three boilers were now dropped from the line and number one carried the load nicely. The firemen were given a few instructions in the firing of a boiler, after which no coal was put through the furnace which was not thoroughly burned. The plant was able to operate now with one fireman and one coal man on each shift, the coal man keeping the ashes removed. This force handled the work with much more ease than all three men had before.

Next, mechanical soot blowers were installed as well as draft gages, damper regulators and a CO_2 recorder. The coal consumption was reduced to about 4 lb. per horsepower-hour, which was considered fairly good for a plant of this kind. W. M. MCNEILL.

Building for the Future

THE LETTERS bearing the captions "Arthur and I" and "The Engineer's Influence" appearing in recent issues of Power Plant Engineering proved of considerable interest to me. There is, however, one thing frequently overlooked and that is the importance of the engineer and the lack of interest many times displayed by him in his work.

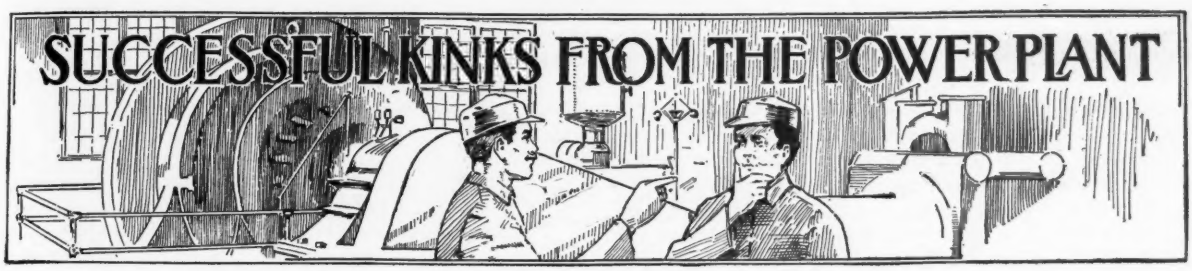
I have operated the engine in a large factory and have no complaint to make against the management and whatever I say in regard to matters relative to my department is accepted as final by all concerned. I have in mind, however, a factory where the manager decided he wanted to augment his power transmission by a rope drive with sheave pulleys and ordered the equipment without consulting his engineer. The result was that when it arrived upon the job he found, much to his dismay, that the bore in the main pulley was too small for the engine shaft with the consequence that reboring, entailing an expense of over $200, was necessary. Even then, things did not materialize as anticipated and he was more or less dissatisfied and set back financially several hundred dollars.

Then, again, the engineer will many times fail to measure up to his job, considering it as a thing similar to a common hand-tool which may be thrown down and picked up at will. I have in mind an engineer who refers to his company as "the company" or "the boss," when in reality it is "his" company. When we draw our pay, it is and should be considered as a dividend and frequently is one greatly in excess of that actually received by the stockholders. If we would all take this view of the matter, we would be more careful of the property in charge of which we are placed.

An engineer I know sits idly and comfortably in his engine room waiting for trouble, and when it does come, attributes the cause to anything and everything other than his indifference and carelessness.

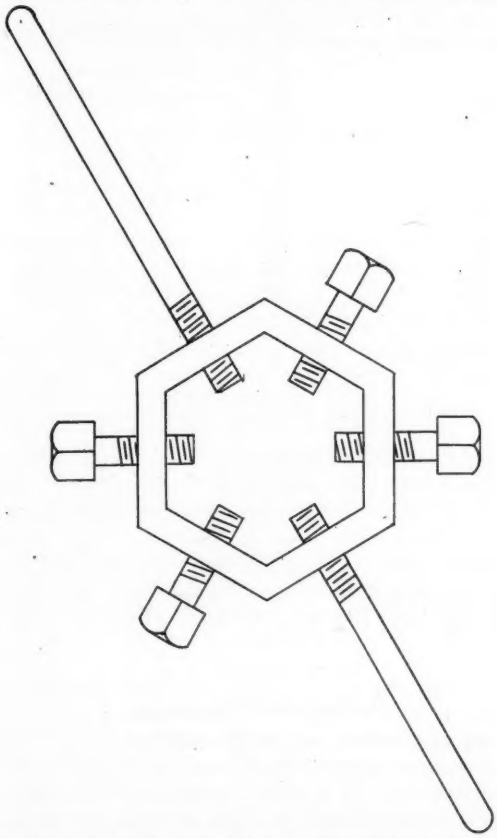
Some engineers look upon the boiler inspector as a "calamity howler" and look with dread upon his coming. That is all wrong. I go into my boilers with the inspector each time he comes and put forth every effort not only to discover that which may be wrong, but also to right the wrong when found.

Mine is a good job and I want to hold it; I also want to live a long time and do well. F. S. HUNT.



Adjustable Nut Wrench

THE ADJUSTABLE nut wrench shown is not a new idea, but its construction is so simple that any engineer can make one like it. The handles can be unscrewed from the frame and the tool packed in a small space. By using



ADJUSTABLE WRENCH FOR LARGE HEXAGONAL NUTS

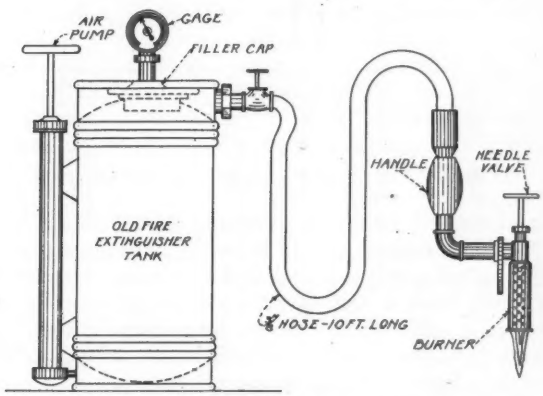
any two opposite bolts, square nuts can be held. Round disc plates can be held with this holder if no guide is required.

J. E. JAMES.

Homemade Hot Blast Torch

THE ACCOMPANYING sketch shows a blow torch made from an old fire-extinguisher and a regular blow torch burner.

The tank holds nearly 4 gal. of gasoline, sufficient to burn the torch for a time of from four to five days. The tank is first cleaned, and the basket taken off the filler cap. The valve stem is removed and the valve stem hole, in filler cap, drilled out with a 23/32-in. drill and tapped with a ½-in. pipe tap. A ½-in. pipe nipple 3 or 4 in. long is screwed into the tapped hole and to this is attached an air or steam pressure gage having a capacity of 100 lb. per sq. in. A regular automobile tire pump is fastened to the tank as shown in the sketch, by two pieces of brass soldered to the body of the pump and tank. An air inlet port connecting with the pump can either be located on the bottom of the tank as shown in the sketch or a second hole can be drilled in the filler cap close to the gage connection and tapped for a ⅛-in. pipe connection and valve. Connection is made between this valve and pump by means of a pipe or hose. This tank has a hose connection on top; to this



HOMEMADE HOT BLAST TORCH

is fastened a ⅜-in. valve for cutting off the gas from the burner when not in use. A ⅜-in. acetylene hose 10 ft. long is connected to the valve, having attached on the other end a handle and ordinary burner as shown. This outfit has sufficient heat to melt brass or copper and easily weld these and is very useful for all kinds of heavy work in its line.

OTTO DORTHEN.

New Use for the House Cat

THE COMPANY by which I am employed had some recent trouble with one of its generators.

On making the application of tests, I found that the leads which ran from the machine to the switchboard had shorted and burned off. These leads ran through a 6-in. duct built of tile and was laid 3 ft. below the floor. It was very unfortunate, as this was the only machine in operating condition at that time. I tried using the fish tape and all other methods employed in replacing wires in duct. I found that the rough joints in the tile would not let the tape pass through, as this was a hurry-up job. Things were getting pretty serious for me about then, as the community was becoming pretty badly riled up. So something had to be done and done

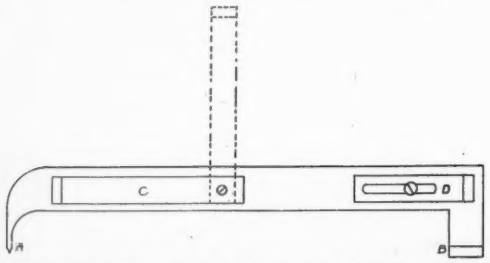
quick. Securing a cat, I took one of my test clips and a strong string, placed the cat up in the duct and snapped the clip to his tail, to which I had the string tied. As this pulled a little on his tail, he pulled and kept pulling until he came out the other end of the duct. In this way, I succeeded in getting a wire through the duct by the string, and was soon fixed up and running again.

One of the company remarked that there is more than one way to skin a cat. This was one way in which I applied it very well. This little kink may be applied to house wiring as well as the largest power plant.

H. CORDNER.

A Four-in-one Screwdriver

THE FOUR-IN-ONE screwdriver shown herewith is not difficult to make and is a very useful tool. Ends A and B are useful when screws are in difficult places to reach with the ordinary driver. By slackening on screw



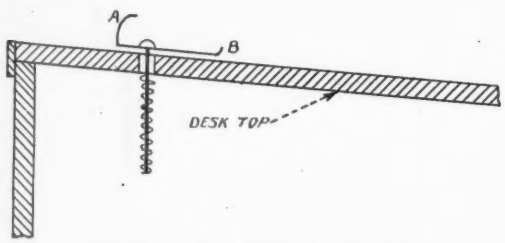
CONSTRUCTION OF THE FOUR-IN-ONE SCREWDRIVER

D and moving the blade along the slotted hole before tightening the screw, a long driver is formed. By moving C into the position shown in the dotted lines, a driver for heavy work is secured. A strong steel screw should be used on this blade. When blades are in place as shown, this driver can be carried in the ordinary rule pocket. Blades can be made of different widths if required.

JAMES E. NOBLE.

Homemade Paper Holder

THE PAPER HOLDER illustrated on page 1003, Oct. 15 number, reminds me of a neat, simple paper holder that can be made in few minutes.



SPRING PAPER HOLDER FOR DESK

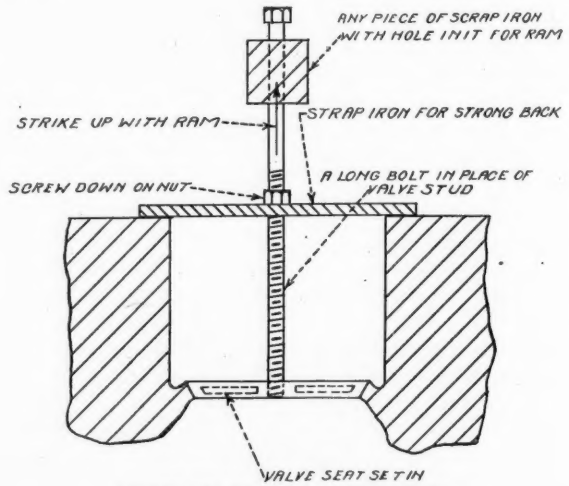
Bend a piece of band iron or any other metal as shown. The iron band can be any width desired, but ½ in. wide is all right. Punch a hole in it to take a ¼ or 3/16-in. bolt. Make a small hole in the desk top and put the holder together as illustrated. If you have no spring, one can be made in a minute by turning a piece of hard brass wire around a piece of ⅛-in. rod. To use, lift A and place papers under B.

I have seen this little holder in use on polished hardwood desks in an up-to-date office. The holder was homemade, but nickel-plated material was used in making it. The idea can be used to make a portable paper holder, in which case a base of wood or metal will have to be added.

JOHN THORNE.

Valve Seat Puller

TO GET OUT the seats on our boiler feed pump, which carries 250 lb. pressure, we use the device shown herewith. The seats are a forced fit and some of them get set very tight, but this rig takes them out.


ANY PIECE OF SCRAP IRON WITH HOLE IN IT FOR RAM
STRIKE UP WITH RAM
STRAP IRON FOR STRONG BACK
SCREW DOWN ON NUT
A LONG BOLT IN PLACE OF VALVE STUD
VALVE SEAT SET IN

DEVICE FOR PULLING VALVE SEATS

A long bolt is put in place of the valve stud with a long thread, and a nut bearing on a piece of heavy strap iron which lies across the opening of the valve chamber. On the bolt is a piece of scrap bored to slide on the bolt and strike upward against the head. By screwing down on the nut, and striking up with this ram, we soon get results and have the valve seat out where we want it.

P. L.

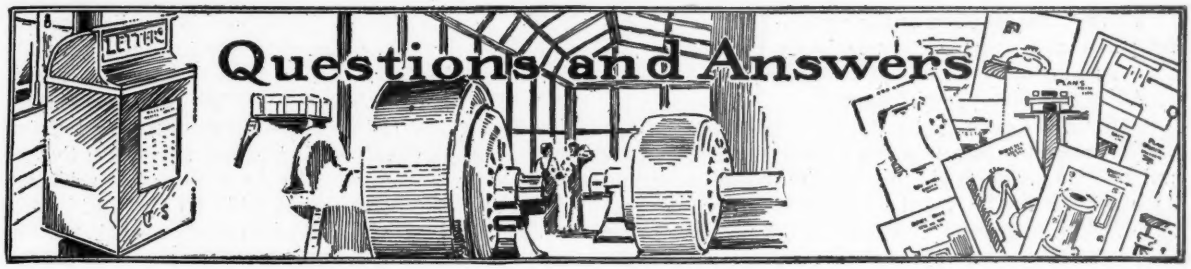
A Serious Omission

SOME mechanical genius, in writing of the merits of the monkey wrench when used in repairing automobiles, wrote: "A monkey wrench should never be drawn backward from the jaw, as this movement is likely to bend the bar. The wrench should always be pulled toward the jaws."

Now, that is very good advice; but as there are so many ladies who attempt to do their own repair work, what I am amazed at is this: Why didn't he add, "A monkey wrench must never be used as a hammer"?

J. B. DILLON.

THE COLORADO Council of Engineers, composed of representative electrical, mechanical, chemical and minor branch societies, heartily endorsed the revision of the present Colorado engineers' license law, which is incorporated in a bill regulating the practice of professional engineers and land surveyors, and creating a board of examiners for engineers, now before the state legislature. The council is contemplating the erection of a large office building in the heart of Denver, which is to be occupied by engineers only.



Repairing Leaky Boilers

WE ARE running a steam-driven ice plant, and have four horizontal return tubular boilers, three of which have fire cracks at the girth seam and are leaking. I tried chalking and also reaming out the rivet holes and putting in new and larger rivets, but was unsuccessful in stopping the leaks. I would like to have the readers of Power Plant Engineering give me their experience along this line and advise me as to how I can prolong the life of the boilers. G. B.

Indicator Card Criticisms, Etc.

A FEW REMARKS about indicator cards on page 142 of the Jan. 15 issue: A. S.'s cards look to me as if the compression line on the head end showed that there was a leaky piston, drip valve or exhaust valves. The head end also does not seem to have any real cutoff, which may be caused by the rider being too far behind and the head-end main valve is wiredrawing the steam. The crank end shows too early compression for an engine running at this speed; this can be remedied by taking off a little exhaust lap on that end.

Except that the head end is doing the most work, I would say that H. A. C.'s cards were good. All that I would do would be to change the cutoff until both cards looked the same.

Regarding T. J. M.'s card, I would say that the wavy line on the high-pressure end might be caused by sticky indicator springs, and that the reason for the expansion going so low is due to a leaky piston or leaky exhaust valves.

"What Caused the Pound?" (Page 140.) This is interesting to me, as I have an engine that acted the same way. I knew that the pound was in the cylinder. It would give four or five distinct knocks, stop for a few minutes, then start again. My piston is of the built-up type, having a long flat spring with a hook at each end for each section. One of the hooks was worn, which left a weak place or an unbalanced piston. A new spring was put in and there has been no trouble since. N. W. L.

THE CARD of A. S., taken from the 14 by 22-in. engine, is good, only the compression line on the head end shows by the outward movement of the pencil that there is a leak either through the exhaust valve or around the piston. Also, admission of steam on the crank end is a little too early, as shown by the outward slant of the admission line. To remedy this, shift the eccentric on the shaft a little so as to decrease its angular advance. This will change all other points a little.

H. A. C.'s card, taken from a Murray-Corliss 18½ by 30-in. engine, shows that the head end is doing most of the work. I also think that a 150-kw. generator, if loaded, is too much for the boiler pressure carried.

The card of L. C. T., taken from a 11 by 12-in. Skinner automatic engine, is fairly good for a high-speed engine. Steam admission is somewhat too early, as shown by the backward slant of the admission line on the head end. This also causes that end to do most of the work. I think he can profit a little by the comment to A. S.

T. J. M.'s cards, taken from a Ball-Wood Corliss cross-compound engine, show that his engine cuts off too early, causing the steam to expand below the back-pressure line. The valves should be so set that the drop from the expansion line to the back-pressure line will occur as nearly as possible at the end of the stroke.

C. C. N.'s card, taken from an Ames Unaflow engine, is very good, only I think that his engine is nowhere near loaded. Try putting on a full load and see whether the improvements in the card at all points will not be more pronounced. LESLIE KLOCK.

Effect of Power Factor on Steam Consumption

I WOULD like to give you my views on C. H.'s problem stated on page 145 of your Jan. 15 issue, as I do not quite agree with the answer given.

From C. H.'s statement, that his output ranges between 3100 and 3500 kw., let us assume that 3200 kw. is his average load. Then 3200 multiplied by the water rate of the turbine would give the steam consumption at any power 60 per cent or 80 per cent, except for the following consideration.

At low power factor, there is a large amount of "wattless" or "reactive" current which passes through the machine and conductors but does not register on the watthour meter, nor is it capable of doing external work. Were it not for the fact that this reactive current requires power represented by the I^2 R. or heating losses, the steam consumption at 60 per cent power factor would exactly equal that at 80 per cent power factor, the true kw. only requiring power at the turbine.

To calculate the extra steam required to develop 3200 kw. at 60 per cent power factor as against 80 per cent power factor, it would be necessary to know the combined resistance of the machine, and distribution lines, when the square of the current, times the resistance would equal the power lost, or it can be calculated by the power loss formula, which for a balanced three-wire, three-phase circuit (assuming such is the case) is,

$$P = 33 \times 12 \times L \div \text{area in cir. mils.}$$

Where P = power lost in watts in the line, I = the current in amperes in each wire of the line, L = the length of the single distance of circuit, and area in cir. mils = area of each wire in the line.

Taking 3200 true kw. as the average load, the apparent power at 60 per cent power factor becomes,

$$\text{Amp.} = 3200 \div (1.73 \times 2300 \times 60) = 1340$$

At 80 per cent power factor,

$$\text{Amp.} = 3200 \div (1.73 \times 2300 \times 80) = 1005$$

Determine the current value for each wire when 1340 and 1005 amp. are flowing in the circuit and substitute these values for I^2 in the power loss formula and solve for the energy lost in the line at 60 per cent power factor and 80 per cent power factor respectively and the difference in kw. multiplied by the water rate of the turbine will give the excess steam consumption of the machine when operating at 60 per cent power factor and 80 per cent power factor approximately. Of course, this does not take into account the increased field heating of the machine or decrease in efficiency, etc., which we can for simplicity neglect. S. D. St. Clair.

Editor's Note.—As we have received a number of contradictions of the original answer to this question, it becomes evident that this original answer was probably in error.

Low Pressure for Soot Blowers

In answer to the question under this caption in the Dec. 15 issue as to the feasibility of using 30 lb. pressure for blowing 4-in. flues, 18 ft. long, I would say that it has been done very satisfactorily by simply superheating the steam used in blowing. This, of course, increases the energy in the steam and makes available a jet of much higher velocity which is capable of carrying the full length of the tube. Jay Bayliss.

Design of Boiler Appurtenances

How much steam pressure will be allowed on a boiler 60 in. diameter ⅜ in. thick, 60,000 lb. tensile strength, boiler double riveted and a factor of safety to be 6.

2. A return-tubular boiler has 1500 sq. ft. heating surface. Give size of grate surface required, also diameter of the safety valve.

3. Find the horsepower of a 9 by 14-in. engine working 150 r.p.m. with mean effective pressure of 50 lb. per sq. in.?

4. How many gallons of water per hour will a steam pump deliver, size 8 in. by 6 in. by 12 in. and 60 strokes per min., allowing 20 per cent slippage.?

J. H. C.

Answers

The allowable steam pressure in a boiler, 60 in. in diameter and ⅜ in. thick, with an allowable tensile strength of 60,000 lb. per sq. in. and a factor of safety of 6 (we take it, instead of 1/6), can be determined from the equation:

$$p = 2t \times st \times e \div D$$

where p = gage pressure in pounds per square inch, t = thickness in inches, st = the allowable tensile strength, e = the efficiency of the joint.

Without knowing the dimensions of the riveted joint, we cannot determine what the efficiency would be, but we will assume for this problem that it is 75 per cent.

Substituting the values you have given us in this equation, we find that

$$p = 2 \times 0.375 \times 6000 \div 6 \times 75 \div 60$$

it will be seen that s_t, the allowable tensile strength, = 6000 ÷ 6, or the ultimate tensile strength divided by the factor of safety. This reduces to p = 93.75 lb.

2. The size of the grate surface required for any given boiler is variable depending upon the kind of fuel burned and the draft available, and any figure that we might give would necessarily be more or less arbitrary.

An approximate figure would be 30 sq. ft. of heating surface per square foot of grate surface, so that if you have 1500 sq. ft. of heating surface, your grate surface should be about 1500 ÷ 30 = 50 sq. ft.

The size of safety valve necessary for this boiler can be determined from the equation adopted by the United States Board of Supervising Inspectors, which is

$$A = 0.2074 \times W \div P$$

Where A = area of valve per square ft. of grate surface. W = pounds of water evaporated per square ft. of grate surface per hour. P = steam pressure.

Not knowing these values in your case, we would simply give you the equation from which you can derive your own answer.

3. The horsepower of an engine is equal to

$$PLAN \div 33{,}000$$

where

P = mean effective pressure.
L = length of stroke in feet.
A = area of piston in square inches.
N = number of effective strokes per minute.

Your problem thus becomes

$$50 \times 14 \div 12 \times 0.7854 \times 9^2 \times 300 \div 33{,}000$$

Simplified, this reduces to, horsepower = 33.5.

4. The number of gallons of water delivered by a steam pump can be determined from the equation: The gallons of water per hour = area of the water piston times the stroke per minute, times 7.5 × (1 — slippage) where 7.5 is the gallons of water per cubic foot.

Using your data, this equation becomes: Gallons = $0.7854 \times 0.5^2 \times 1 \times 60 \times 60 \times 7.5 \times 0.8$ = 4241.25 gal per hr.

Quality of Steam

Will you please answer the following questions? The following results were obtained from a separator calorimeter test: Weight of dry steam 12 lb., weight of water separated 8 oz., radiation loss 2 oz. What is the quality of the steam?

2. The data from a throttling calorimeter test are as follows: Steam pressure, 85 lb. (absolute); pressure in calorimeter, 25 lb. (absolute); temperature in calorimeter, 266.5 deg. F. What is the quality of the steam?

3. What is meant by the expression equivalent evaporation from and at 212 deg. F.?

4. What is the equivalent evaporation when a boiler evaporates 1900 lb. of water per hour, the gage pressure being 115 lb. and the temperature of the feed water 80 deg. F.? What is the horsepower of the boiler?

5. A lever safety valve is set to blow off at 65 lb.; the ball at the end weighs 110 lb.; the lever weighs 48 lb., and has its center of gravity 18 in. from the fulcrum; the valve is 4½ in. from the fulcrum. The valve has a diameter of 4½ in. and with the spindle weighs 14 lb. At what distance from the fulcrum must the ball be placed? N. B. N.

ANSWERS

THE QUALITY in steam as determined by the separating calorimeter, using the data you have given us, is $X = W \div (W + w) = 12 \div 12.625 = 95.05$ per cent.

2. The quality of steam as determined by a throttling calorimeter is

$$X = (i_2'' + c_p(t_2' - t_2) - i_1') \div r_1$$

where i_2'' = the total heat content of dry saturated steam at 25 lb. absolute pressure, t_2' = the temperature in the calorimeter, t_2 the temperature of saturated steam at calorimeter pressure, i_1' = the heat of the liquid at 85 lb., r_1 = the heat of vaporization at 85 lb. pressure, c_p = the main specific heat of superheated steam at 25 lb. pressure between the temperatures t_2' and t_2.

Substituting these values in the foregoing equation, we get

$X = [1160.4 + 0.475(266.5 - 240.1) - 286.3] \div 897.1$ which reduces it to $X = 98.83$ per cent.

In passing, I might say that this method of determining a steam quality is not accurate for more than three or four per cent moisture in the steam.

3. The equivalent heat of evaporation from and at 212 deg. F. is equal to the factor of evaporation times the actual evaporation under the conditions in which the boiler is operating. The factor of evaporation is equal to the total heat of the steam under actual conditions minus the heat of the liquid divided by the total heat in dry saturated steam at 212 deg. and atmospheric pressure.

4. The equivalent evaporation of a boiler which evaporates 1900 lb. of water per hour at gage pressure of 115 lb., with feed water at 80 deg. F., is thus $(1191 - 80 + 32) \div 970.4 = 1223 \div 970.4$, or 1.261.

The horsepower of this boiler is the actual evaporation times the factor of evaporation divided by 34.5, which is the pounds of steam evaporated from and at 212 deg. per hour per horsepower, which in this case is equal to

$$1.261 \times 1900 \div 34.5 = 69.5$$

5. The distance at which the counter weight should be hung on your safety valve can be determined from the following equation:

The pressure on the valve times the area of the valve times its distance from the fulcrum is equal to the weight of the valve times its distance from the fulcrum, plus the weight of the lever arm times its distance, plus the weight of the ball times its distance. Using the figures you have given, we can reduce this to

$4.5 \times 65 \times 0.7854 \times 4.5^2 = 4.5 \times 14 + 48 \times 18 + 110 \times X$ where X is the distance sought.

Solving this equation for X we get

$$X = (4660 - 927) \div 110 = 34 \text{ in.}$$

Heating Feed Water

ONE THOUSAND pounds of steam at 212 deg. is conveyed by pipes through a building, all the steam is condensed and the water of condensation returns to boiler at a temperature of 192 deg.; if the heat given off is applied to a quantity of water, how many pounds will it raise from 32 deg. to 112 deg.? O. L. Z.

A. A pound of steam at 212 deg. will give up 966 B.t.u. when condensing. If the water of condensation is cooled to 192 deg., the drop in temperature from 212 deg. will release 20 B.t.u. per pound. This added to the 966, gives 986 B.t.u. given up per pound of steam, or 986,000 for 1000 lb.

To heat a pound of water from 32 deg. to 112 deg. will require 80 B.t.u. and this, divided into 986,000, gives 12,325 lb. of water heated.

Bleeding Steam from the Receiver of a Cross-Compound Engine

QUITE a controversy has arisen in our mechanical department as to whether or not the sketch, shown herewith, is good practice and feasible. Would it be advisable to take a part of the steam from the receiver of our cross-compound engine and use it for other purposes, for example, to heat water through the medium of a coil of pipe placed in a tank?

We wish to use approximately 10 per cent of the steam for this purpose, governing this by throttling a valve, as the load is very steady. The data is as follows: Size of engine, 26 by 52 by 48 in.; r.p.m., 90; i.hp., 1200; steam pressure, 135 lb.; receiver pressure, 8 lb.; vacuum, 25—27 in.

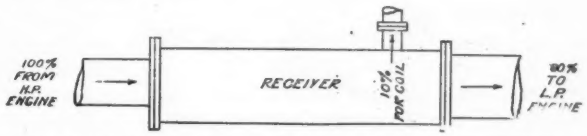


DIAGRAM OF THE RECEIVER AND BLEEDER CONNECTION

Can it be done as shown, and what effect will it have on the efficiency of the engine? C. N. S.

A. In regard to bleeding steam from the receiver of compound engines for the purpose of heating a factory or for industrial use, I would state that this has been used to advantage in a number of industrial plants, and if your valves are properly set this practice should give you no particular difficulty.

It corresponds closely to the system of bleeding which is a common practice where steam turbines are used in plants and where low-pressure steam is also required.

Grate Area

WHAT WOULD you consider the proper grate area for a boiler having the following dimensions: Length, 15 ft.; number of tubes, 64; diameter of tubes, 3 in.? H. V. F.

A. The 3-in. tube requires 1.273 ft. of length per square feet of heating surface, so that a 15-ft. tube would have 11.8 sq. ft. and 64 tubes would have 755 sq. ft. Allowing 10 sq. ft. per horsepower, this would give us about 175 hp. boiler.

The common rule is to allow 1/3 sq. ft. of grate surface per horsepower, which would give 25 sq. ft. of grate needed. This is an allowance of 5 lb. of coal per hour per boiler horsepower and 15 lb. of coal burned per square foot of grate per hour.

Boy, Page Mr. Ananias

CHIEF (on phone): "What's the matter with the steam?"

Fireman: "Not a thing, chief, only I wasn't tending to my job."

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Advances in Power House Design

But few are the pieces of apparatus comprising the equipment of modern power plants which, within the last decade, have not undergone more or less decided changes of design and construction tending toward greater economy of raw materials required in the production process and a higher overall efficiency. Simultaneous with these equipment changes have occurred as important, if not as marked, changes in the construction of the power houses proper.

Unless local conditions, apart from those of a purely engineering nature, necessitated the contrary, steam generating units were placed upon a mat of brick work or, later, reinforced concrete and all auxiliary equipment installed in this part of the plant either directly upon the floor or upon foundations which in reality formed an integral part of the flooring. Similar arrangement was employed in the engine room, although frequently, because of the heavier and bulkier foundations required for the prime movers, a low-head basement was provided. As a rule, this space which was unlighted, unventilated and difficult of access was utilized for the storage of repair parts, discarded equipment and occasionally for the installation of apparatus such as traps, oil filters, etc.

Increased land values and building costs, changes in the design, construction and arrangement of equipment, improved means of operation and the safety and welfare of employes are factors to which may be attributed the present-day style of power house architecture employed. Although overhead bunkers extending the entire length of the boiler house are still in use, the tendency is toward the placement of these at one end or side of this part of the plant and the employment of traveling weigh larries for the distribution of the coal to the stoker hoppers. This leaves the space above the firing aisle free and permits natural lighting and ventilation otherwise restricted.

With the type of apparatus found installed in power plants today high-head basements under both boiler room and engine room are necessary. Without this, many types of stokers with their schemes of ash disposal would prove impracticable, and much of the auxiliary equipment such as stoker engines, forced draft fans and pumps of various kinds would of necessity be placed upon the boiler room floor, thus adding to the floor space required and consequently to land and building costs.

Another noticeable advance in power plant design due undoubtedly to the ever increasing size of steam generators being built are the means now available to bring all operating parts of the boilers within reach of the attendants, thereby eliminating the otherwise hazardousness of boiler-room work and reducing to a minimum the time required for quick action in the event of an emergency. In all but the very smallest installations, boiler accessories such as pressure gages, water gages, water column cocks, shutoff valves, safety valves, etc., are now readily accessible through the medium of substantial stairs, platforms and alleyways which form permanent features of equipment.

Without engine room basements the use of some types of surface condensers would be almost practically impossible. This is particularly true in the case of surface condensers operating in conjunction with steam

turbines requiring a high degree of vacuum and obtainable only through the shortest connections possible.

At best these basements have heretofore been unlighted, except by artificial means, and unventilated, conditions conducive to more or less neglect of the equipment there installed. Modern design, however, corrects this. Depth of the basement is increased and large open areaways are provided to make the engine or turbine room floor more of the nature of a balcony, in that manner permitting the access of light and air to the condenser floor and a ready view of all operating equipment. Naturally, such an arrangement will result in improved operating conditions and insure better care of the otherwise more or less neglected apparatus.

As the size of an electric generating plant increases and higher voltages are employed, extensive bus structures and larger switching and control equipment are required. Obviously this cannot be installed on the turbine room floor and unless separate switch houses are provided—arrangements desirable only in the case of the very largest plants—this equipment also must of necessity be placed in the basement.

Crowding of equipment in any part of the plant is a practice worthy only of severe condemnation. Accordingly it is desirable, both for the sake of safety and elimination of excessive building costs, to place as much of the electrical apparatus as is possible out of doors. Manufacturers now build power and instrument transformers, oil switches, lightning arresters, and high-tension busses applicable to this kind of service.

Off Duty

Those of us who came into the game early will recall with what feeling of admiration we welcomed the first weak, yellow, carbon incandescent lamp—how we applauded its supremacy over previous forms of artificial illumination. Those of us who were so fortunate as to be able to visit the Chicago Exposition in 1893 came away impressed with the splendor of the illuminating features, the parallel of which had never been achieved before. That was 28 yr. ago.

Today, the carbon lamp of yesterday is no more. It has given way to its more efficient and highly developed successors, the tungsten and the high-powered, gasfilled lamps of the present day, the advent of which is only another remarkable illustration showing the application of the results of pure scientific research to a practical engineering problem.

The discovery of inert, or noble gases as they are termed, which fill the incandescent lamps of today was purely a scientific achievement, and had not the remotest connection with the lamp industry. Spectroscopic analysis first revealed the presence of Helium on the Sun, from which it received its name. It was later found to be one of the constituents of the atmosphere and was finally isolated in the laboratory. Argon, was the outcome of an investigation conducted by Sir Wm. Ramsay and Lord Rayleigh, for the purpose of determining why nitrogen obtained from air was never so pure as nitrogen obtained from some compound. Argon was found to be the impurity. Neon, Krypton, Xenon, etc., were discovered to belong to the same class—they were inert, i.e., they would not form chemical union with other elements nor with themselves. Apparently, they were useless.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Similar to the discovery of these gases, the investigation regarding the destruction of filaments with consequent blackening of the bulbs in exhausted incandescent lamps was purely a scientific undertaking. Yet the combined results of these two separate lines of research have served to produce our highest type of illuminant.

The latter investigation disclosed the fact that the substance of which filaments were made evaporated when heated to a high temperature in a vacuum, just as water does when heated to the boiling point. And just as steam condenses upon striking a cool surface, so did this vaporized metal condense on the cool walls of the bulb. Rather an interesting comparison, isn't it?

Now, we know very well that when the steam gage on our boiler registers 200 lb. the temperature of the water in the boiler is 388 deg. We also know that at atmospheric pressure, water will boil at 212 deg. Why these differences in temperature? Because of the difference in pressure. When we increase the pressure, we raise the boiling point.

It was reasoned, therefore, that if the pressure inside the electric bulb could be increased the boiling point of the filament would be correspondingly raised and evaporation would be reduced. Such proved to be the case. When the bulb was filled with a gas under pressure, disintegration of the filament ceased.

The gas used in the lamps, however, must be inert—they must not combine chemically with the filament material. Oxygen, of course, would not do, since the filament would burn. The inert gases possessed all the necessary qualifications and so, today, incandescent lamps are filled with Argon and Neon—gases which were previously thought useless.

An Apology

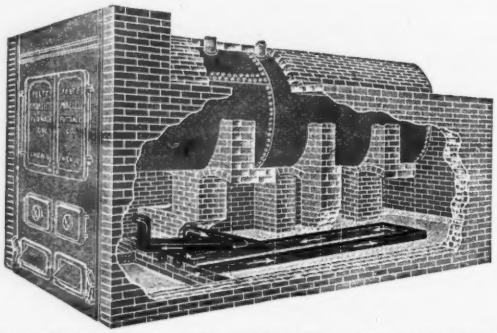
The articles on "An Invention That Brought the World Together" appearing on page 1136 in the Dec. 1, 1920, issue and on page 1180 in the Dec. 15 issue, which were sent us by the man whose name appears as author, purporting to be original matter, have been discovered to be copied, almost word for word, from the first chapter of "The History of the Telephone" by Herbert N. Casson, published by A. C. McClurg & Co., of Chicago, Ill., and copyrighted.

The editors of Power Plant Engineering greatly regret this circumstance and hereby make apologies to A. C. McClurg & Co. for the publication of this material without credit and also acknowledgment of the source in which the matter first appeared.

Preheating Air Increases Furnace Efficiency

IN THE usual run of furnaces where all the air for combustion is supplied through the grate, much of the volatile combustible matter of the fuel passes up the stack unconsumed because of the fact that the intimate mixing of the gases and air does not take place close enough to the incandescent fuel bed where the combustible gases have a temperature sufficiently high for ignition. It is delayed, instead, until the temperature has dropped below this point, consequently the gases are not completely burned and just that much heat is lost. In addition to this loss, these gases deposit soot on the relatively cool heating surfaces, which reduces the heat-transmitting qualities, cutting down the boiler efficiency and consequently the overall efficiency.

By preheating a portion of the air required for combustion and admitting it above the fire at about 500 to 1000 deg. F., it is possible to save a large part of this loss, according to the claims of I. W. Foltz, who has designed a preheating appliance for installations that are violating the smoke ordinances or that are not coming up to expectations in the way of efficiency.



INSTALLATION OF AN AIR PREHEATER ON A HORIZONTAL RETURN TUBULAR BOILER SETTING

Part of the air, about 15 to 20 per cent, that is admitted to the ash pit is passed into an airtight duct. This duct has its mouth in the base of the bridge wall or in the side walls just under the grate. It then comes out on the floor of the combustion chamber back of the bridge wall, extends to the rear of the setting and back again to the bridge where it enters the side walls and is carried up above the grate, discharging just over the fire near the front of the furnace as shown in the accompanying figure. These ducts are installed in pairs, one admitting air on each side of the grate. They are constructed of tile or fire brick closely cemented together.

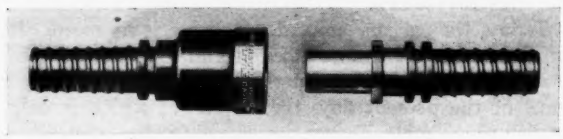
By admitting this high temperature air directly over the fire where it is most needed, an intimate mixture of hot gases is obtained and combustion improved. To reduce stratification further, the bridge wall is built high and a pier is put in at the center which is built up to the boiler shell. Wing walls are built up behind the bridge and a pier is constructed around the blowoff pipe. In designing this apparatus for any particular setting, the grate surface, flue area and combustion space are considered. The pass over the bridge wall is made about 25 per cent greater than the flue area. The size of the duct depends on the size of the grate, thickness of fire, draft required, resistance of the duct itself and the temperature at which the air is to be delivered.

One of these appliances has recently been installed in one of the 375-hp. horizontal water-tube boilers of the N. K. Fairbank Co. of Chicago. This boiler is equipped with a chain grate and burns low grade Illinois screenings. The usual rating at which this boiler is forced is about 180 per cent. The duct area on this setting is approximately one per cent of the grate area. In a comparative test between this boiler and another one of the same battery, the engineer states that it showed an increase in efficiency of approximately 12 per cent, and that the evaporation from and at 212 deg. F. was 6.8 lb. of water per lb. of coal. The CO_2 readings averaged about 11 per cent, indicating about 75 per cent excess air, which he claims is far below the average for the other boilers.

It was, of course, impractical to observe the smoke conditions of this one boiler in a large battery, but the fire appeared particularly clean at the edges. In an installation of horizontal return tubular boilers where every boiler in the battery was fitted with a preheater, no smoke was visible and the tubes were practically free from soot. The boiler was provided with soot blowers, but they were used only once every two days instead of once every shift as had previously been the custom. This plant had been having some dealings with the city smoke department, but is now enjoying peace.

New Air Hose Coupling

HOSE couplings which become leaky after short use are the cause of serious air losses, whether in the small shop or the large plant using hundreds of hose connections. Another trouble commonly experienced with many couplings is jamming or sticking through some slight injury, making them difficult or almost impossible to connect or disconnect.



PARTS OF NEW AIR HOSE COUPLING

The design of the Little David coupling recently has been with the view to overcoming these troubles. Its main features are its sturdiness and simplicity, and an all around ability to stand lots of abuse without affecting its service.

The female end is fitted with a V-shaped rubber gasket providing an air-tight joint. The gasket is prevented from blowing out should the coupling accidentally be disconnected under pressure, by a protective shoulder inside the coupling. The female has no exposed parts which might be liable to injury and cause jamming or sticking. The parts are made of a metal not subject to ordinary rusting or corrosion.

A very liberal bearing between the ends of the coupling assures alinement and long wear. The air ports are straight and of uniform diameter, offering least

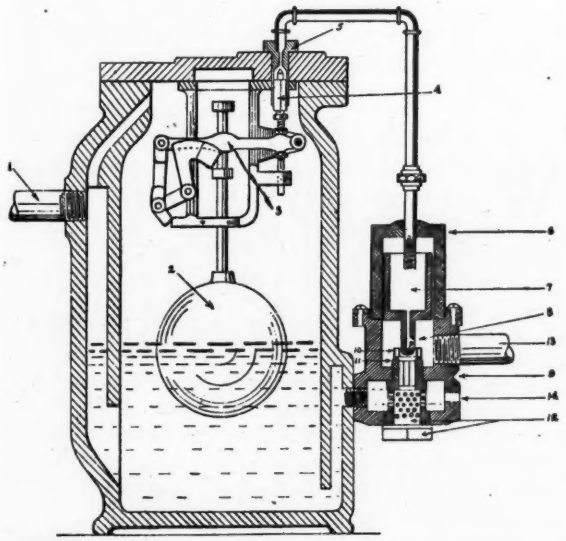
restriction to the air. The coupling may be connected or disconnected by a quarter turn. A groove in the hose end of each part allows using a hose clamp to attach securely to the hose.

A Quick-Acting Steam Trap

HEREWITH is a drawing of a steam trap that has just made its appearance. It is claimed that the action of the discharge valves is extremely quick, opening wide and closing almost instantaneously.

Referring to the drawing, 1 is the inlet; 2, float; 3, lever; 4, pilot valve; 5, pilot valve seat; 6, valve cylinder; 7, piston; 8, air vent; 9, valve body; 10, valve disc; 11, valve seat; 12, valve seat holder and strainer; 13, outlet; 14, sediment blowout.

The operation is essentially as follows: The float, 2, holds the lever, 3, down, pulling the pilot valve, 4, off its seat. The steam pressure in the trap is communicated to the piston, 7, closing the discharge valve.



SECTION OF THE STEAM TRAP SHOWING FLOAT CONTROLLED PILOT VALVE AND DISCHARGE VALVE

As the condensate accumulates in the trap, the float rises until it trips the lever, 3, and closes the pilot valve, cutting off the pressure on the piston; 7, an air vent; 8 releases the pressure in the cylinder, 6, and the pressure in the trap opens the discharge valve wide, allowing the water to escape through the outlet, 13. As the float falls, it again trips the lever, 3, and opens the pilot valve which causes a closing of the discharge valve.

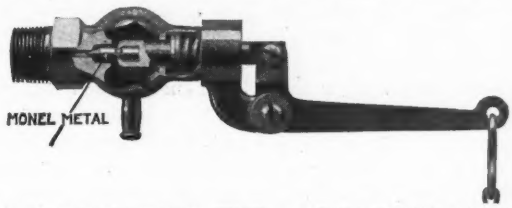
It is claimed that a valve of this kind for a 1½-in. line will discharge 50,000 lb. of water per hour.

A New Gage Cock

A GAGE COCK designed especially to make use of the properties of monel metal in resisting steam cutting and corrosion is shown herewith.

The pointed monel metal cone seats against the pressure on a narrow seat of steam bronze. The seat is not ground, but made tight by tapping with a hammer on the projecting end of the stem.

The design is such that the valve stem gets the same alinement without any binding every time it is operated and the cone always seats in the same position. The cone is held on the seat against the pressure by a copper coated steel spring which has a large factor of safety for pressures up to 350 lb. Every time the cock is operated, the steam or water blows the seat and cone clean and the



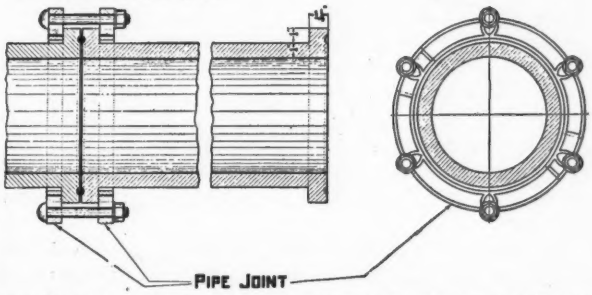
A GAGE COCK FITTED WITH A MONEL METAL VALVE

erosive action comes on the monel cone which is the best known material to resist it. When used on bad water where it is necessary to clean out lime deposits, this can readily be done, as all ports and passages are straight and accessible. A small packing is placed around the stem to cause all the discharge to take place through the nozzle. The cock is operated by a single chain pull.

An Improved Flange Joint for Steam Jet Ash Conveyor Piping

THE EXTREME simplicity of the steam jet ash conveyor would at first seem to preclude any possibility of design; however, some changes have been made which may at first seem minor, but later produce considerable economy. Among these is a new type of flange construction illustrated herewith.

The heavy cast-iron piping for steam jet ash conveyor use has in the past presented a problem in flange joint construction. The three factors to be dealt with in this connection are:



SECTION OF PIPE JOINT SHOWING METHOD OF CLAMPING FLANGES TOGETHER

First, absolute necessity of an airtight joint to prevent losses in suction on the intake line. Second, ash conveyor piping is made of extra hard cast iron to withstand the abrasive action of ashes and is consequently more or less brittle. Direct flange connection by means of bolts causes excessive breakage of flanges due to uneven tightening of bolts. Third, piping must be free to be turned any number of degrees to offset wear in order to give piping maximum length of life.

The manufacturers of one type of steam jet ash conveyor have overcome all these difficulties in the design of the pipe joint, which has been tried in actual service for sufficient length of time to prove its merit.

The pipe flange is cast solid and pipe connections are formed by the use of a flange coupling or collar, cast in two sections to form a circle that girdles the pipe just ontside the flanges. Bolts connecting these collars draw them together with the pipe flanges between, forming a perfect joint without strain on the pipe. The pipe flange is 1¼ in. thick and projects only 1 in. from the body of the pipe. This gives sufficient clearance for the bolts connecting the collars. Tightening of these bolts brings the two sections of pipe firmly together. The slight projection of the flanges offers little chance for breakage in handling or shipping.

The pipe end is grooved 1 in. from the inside surface of the pipe to receive a rubber ring gasket to complete the airtight joint and at the same time permit the necessary flexibility to provide for expansion of pipe. The gasket can easily be inserted after pipe flanges are brought close together.

Another advantage of this movable flange coupling over the direct flange coupling is that it entirely obviates the trouble of non-alinement of bolt holes when cast in pipe flange. In many cases when pouring flanges with bolt holes, the core is bound to slip a trifle and cause this trouble.

Results of Godfrey Conveyor Co. Contest

DURING the month of November, 1920, the Godfrey Conveyor Co., Elkhart, Ind., conducted a contest among users of Godfrey conveying machinery, giving prizes to those entering who handled the greatest amount of coal over a period of time. In judging this contest such details as the following were taken into consideration: Weight of coal, size of lumps, distance bucket was raised, lowered and conveyed, the size motor that was used for power and the time consumed in the operation.

Results of the contest are now given out and below is published a list of the companies winning the prizes:

First prize $50: Hilligoss & Son of Shelbyville, Ind., on Nov. 4, 1920, unloaded 96,600 lb. of lump coal and conveyed it to storage 87 ft. from the railroad siding in 1 hr. and 18 min. Each bucket load was raised and carried at a height of 30 ft. and lowered to ground storage.

Second prize $25: The Finch Coal Co., of Kokomo, Ind., on Nov. 19, 1920, unloaded 94,200 lb. of lump coal and conveyed it to storage 150 ft. from the railroad siding in 1 hr. and 40 min. Each bucket load was raised and carried at a height of 50 ft. and lowered to ground storage.

Third prize $15: W. G. Block Co., Fairfield, Ia., on Nov. 30, 1920, unloaded 103,000 lb. of large egg coal and conveyed it to storage 50 ft. from the railroad siding in 1 hr. 30 min. Each bucket load was raised and carried at a height of 50 ft. and lowered to ground storage.

Fourth prize $10: Fred Scherer, of Ottawa, Ill., on Nov. 18, 1920, unloaded 96,800 lb. of lump coal and conveyed it to storage 32 ft. from the railroad siding in 1 hr. and 32 min. Each bucket was raised and carried at a height of 56 ft. and lowered to the bottom of the storage bins.

Fifth prize $10: Edwards Coal Co., of Ames, Ia., on Nov. 18, 1920, unloaded 96,600 lb. of large egg coal and conveyed it to storage 40 ft. from the railroad siding in 1 hr. and 28 min. Each bucket load was raised and carried at a height of 40 ft. and lowered to 24 ft. to storage.

Sixth prize $10: Quincy Coal Co., Quincy, Ill., on Nov. 4, 1920, unloaded 93,600 lb. of large lump coal and conveyed it to storage 110 ft. from the railroad siding in 2 hr. and 57 min. Each bucket load was raised and carried at a height of 52 ft. and lowered to bottom of storage bins.

First honorary mention: W. J. Baker Co., Janesville, Wis., on Nov. 16, 1920, unloaded 13,340 lb. of lump coal and conveyed it to storage 70 ft. from the railroad siding in 3 hr. and 5 min. Each bucket load was raised and carried at a height of 40 ft. and lowered to ground storage.

Second honorary mention: Manhart Coal Co., Northfield, Minn., on Nov. 9, 1920, unloaded 93,740 lb. of anthracite stove coal and conveyed it to storage 20 ft. from the railroad siding in 1 hr. and 40 min. Each bucket load was raised and carried at a height of 40 ft. and lowered to the bottom of pockets.

Death of W. F. Warden

W. F. WARDEN, president of the Burt Manufacturing Co., of Akron, O., passed away on Jan. 19 at Deland, Fla., death being due to acute heart disease. Burial was at Wadsworth, O.

After receiving his early education and learning the printer's trade at the Soldiers' and Sailors' Orphan Home at Xenia, O., Mr. Warden followed his chosen line of work for a number of years in various parts of the country, rounding out his career in the printing industry as editor of the Wadsworth Banner. Finally, however, he located in Akron and become identified with the Burt Manufaeturing Co., which later, through his careful management, grew from a small business to the institution of its present size.

In addition to being president of the Burt Manufacturing Co., he was also president of the Burt Building Co. and vice-president of the Akron Gear & Engineering Co., a member of the local Chamber of Commerce and of the Portage Country Club.

He was an extremely likable man and leaves a host of friends to mourn his loss. A widow, Ida May Warden, and two sons, William F., Jr., and Donald survive him.

News Notes

AN ALLOYS Research Association is being formed with an Alloys Informational Service as the first step. This is to be co-operative on the part of those interested in metals and their alloys. An advisory committee, composed of 17 prominent technical men, was formed some time ago and this committee has evolved a plan, in conference with the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, whereby a service of a different scope from any now existing can be carried on for the benefit of the alloy men. It has been felt that it is time to broaden

the sources of knowledge and to have a co-operative service that will critically and analytically digest the great mass of data that has been accumulated, but is now largely inaccessible. Technical men have not the time to spend in searching even all of the current literature. It is now planned to create a special scientific staff composed of a director and a corps of assistants who will give all their time to rendering a service of two distinct types: (1) current informational service—supplying information as to new results; (2) reference service—supplying as fully and promptly as practicable all existing information relating to any phase of a subject. The board of managers appointed by three of the divisions of the National Research Council, is constituted of Alfred D. Flinn, secretary of the Engineering Foundation; Dr. R. B. Moore, of the Bureau of Mines, and W. M. Corse, secretary of the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers.

Co-operation and information can solve many of our problems. The first act of the administration at the great industrial research laboratory at Grosslichterfelde is to put the inquirer abreast of the literature of the whole world and the claim is made that 80 per cent of the problems referred to that great German central laboratory can be answered by existing recorded information to which the great card catalog there furnishes the key.

The Research Extension Division of the National Research Council, Washington, D. C., which is aiding in the organization, will be glad to supply fuller details about this service.

EDW. R. LADEW CO., INC., of New York City, tanners and leather belt manufacturers since 1835, have closed their sales office at Charlotte, N. C., and transferred their southern headquarters to 95 South Forsyth St., Atlanta, Ga.

E. D. KELLOGG has recently been appointed New Jersey representative for the Conveyors Corporation of America—formerly American Steam Conveyor Corporation. He will handle "The American Trolley Carrier" and "The American Steam Jet Conveyor" in the Northern half of the state, but will make his headquarters at the Eastern office, 110 West 40th St., New York.

THE COMBUSTION ENGINEERING CORP. announces the opening of a branch office in Atlanta, Ga., at 521 Candler Building. This office has been placed in charge of A. A. Hutchinson, who has had an extensive experience in the engineering field and is widely known in the South, having been actively engaged in the field of combustion generally for the past 14 yr. and during that period been in charge of important development work.

THE MOUNT Spokane Power Co. is successor to the Little Spokane Light & Power Co. by change of name. The company owns and operates two hydroelectric plants in the canyon of the Little Spokane River, one mile below Milan, and 265 acres of land and flowage rights on both sides of the river; owns also 26 mi. of high tension lines and 13 mi. of secondary lines, serving the towns of Deer Park, Milan, Chattaroy, and Denison, and irrigation pumps and residents in Arcadia Orchards, as well as other farmer lines. From a small beginning some 12 yr. ago, the business and physical properties of the company have increased ten-fold in value.

Amended articles of incorporation authorizing the company to issue $50,000 of prior preferred stock drawing 7 per cent cumulative dividends have been accepted and filed by the Secretary of State. The company reserves the right after 5 yr. to call in and redeem the preferred stock at a premium of $5 per share, thus making the stock pay 8 per cent per annum.

In order to raise funds speedily to complete the installation of the machinery without delay, so as to take care of the increased business now in hand, the first $20,000 of the preferred stock will be sold at 97½ thus netting 8½ per cent per annum for 5 yr. In addition, the preferred stock has the security of the prior right in the company's assets over the common stock.

The holder of the preferred stock also has the option to exchange one-fifth of his stock at the end of 5 yr. for an equal amount of the common stock at $125 per share of common stock thus exchanged.

AT A MEETING of its stockholders the Lumen Bearing Co. recently decided to increase the capital stock of the organization to double approximately its present capitalization. The specific reason for this action is that the company has in view the development of its plant equipment to facilitate the handling, for some years to come, a volume of offered business which exceeds the best production of any year since its organization.

It is significant that this increase in capitalization is actuated by the decisions of the staff of the company, who are its largest stockholders, and who probably will retain a large share of the new issue of stock. This statement emanating from a company which enjoys a reputation for a knowledge of sound manufacturing conditions in the brass industry, is indicative of the early revival of active industrial conditions.

The company is expanding to meet its earnings of $500,000, of which $100,000 is to be distributed to the present stockholders as a stock dividend of 50 per cent. The balance of the new issue is to be used to take care of a very rapidly increasing business.

The executives of the company are as follows: W. H. Barr, president and treasurer; C. H. Bierbaum, vice-president; N. K. B. Patch, secretary; N. F. Young, assistant treasurer; H. P. Parrock, general manager; L. S. Jones, general sales manager.

The company has plants at Buffalo, N. Y., and at Youngstown, O. The combined capacities of the two foundries approaches 15,000,000 lb. per year. The company anticipates a very prosperous year for the season of 1921.

U. S. CIVIL SERVICE COMMISSION announces an examination for assistant engineer, receipt of applications to close March 15, 1921, to fill a vacancy in the Engineer Department at Large, Chattanooga, Tenn., at $4000 a year, and vacancies in positions requiring similar qualifications, at this or higher or lower salaries. The duties of the appointee will include supervision of the preliminary report of the survey of the Tennessee River covering the potential development of its water resources, including navigation and the relation to navigation of possible hydroelectric development, flood protection, water supply, etc., and the extent to which such develop-

ment would affect the United States, the States, municipalities, and private interests. Competitors will be rated on education and general engineering experience, special experience and fitness, and must have reached their thirtieth but not their seventieth birthday on the date of the examination. Apply for Form 1312, stating the title of the examination desired.

Book Reviews

"Powdered Coal as Fuel," by C. V. Herington, 324 pages, 6 by 9 in., cloth bound, 124 illustrations.

After discussing the general operation of a power plant, Mr. Herington gives a comparison of the costs of pulverized coal, fuel oil and gas. He then goes on to consider the coals suitable for pulverizing, the methods employed in the process and the actual feeding and burning of the product.

The application of this fuel to reverberatory and metallurgical furnaces, and to boilers, both stationary and locomotive, is then taken up. The subject of explosions and storage difficulties is also given due consideration. Tables of interest to the combustion engineer are included as well as a chapter of specific instructions for firing for the operating engineer. Some ever helpful "Don'ts" are also here tabulated.

The book is plentifully supplied with illustrations showing installations for various purposes, and drawings of furnaces, feeders and other apparatus used in the manufacture of pulverized coal.

Mr. Herington has been in a position to view this subject from all angles and the result is a publication well worth while for the combustion engineer and anyone interested in pulverized fuel.

Practice of Lubrication, by T. C. Thomsen; 607 pages, 6 by 9 in., 227 illustrations, cloth; New York, 1920.

In the preface the author calls attention to the development taking place in the science of lubrication, and to the importance of having the system for lubricating machinery as nearly perfect as possible. Actual results under working conditions are the important objective, and to achieve these it is necessary to have the assistance of the chemist in studying lubricants and deposits, as well as to watch the effects on bearings of the machinery in operation.

The book is divided into 35 chapters covering the various classes of lubricants, methods of testing, different kinds of bearings, laws of friction, requirements for machinery of all kinds, oil for use in cutting operations and for cooling, and recovery and purification of oil. Of special interest are the chapters on Steam Turbines and on Steam Engines, because the matter is timely, and because much detailed information is given that has not, heretofore, been readily available. The author has rendered a service to industry in putting this material into convenient and accessible form.

Connecting Induction Motors, by A. M. Dudley; 252 pages, 289 illustrations, first edition, 1921; New York.

Essentially this book is for the practical man, the armature winder, the motor repair man, the trouble shooter and, in fact, anyone having aught to do with the maintenance of alternating-current induction motors. The style of presentation also is such as to appeal to the man on the job, the text in general being practically entirely devoid of anything but the simplest form of mathematics and this it is evident from a perusal of the book, has been employed only where actually necessary. Exceptionally clearcut diagrams of connections and illustrations enhance the value of the book as an aid to the practical electrical worker.

Chapters I and II are primarily devoted to a consideration of the theory underlying the operation of the induction motor, and Chapers III and IV to the various types of winding employed and the effect of coil throw on the magnetic field. The relationships of the various kinds of windings to speed, frequency and speed are discussed in detail in the following chapters, while in Chapter X is taken up the methods applicable to the reconnecting of an old winding for new conditions. Locating faults in induction motor windings, methods for calculating new windings for old cores, standard group diagrams from 2 to 14 poles and wave windings are subjects considered in Chapters XI and XIV, inclusive.

Trade News

The Adamson Mfg. Co., East Palestine, Ohio, has added a new department for the manufacture of storage, pneumatic and pressure tanks, welded pipe, battery casings, evaporators, condensers and a large line of arc-welded products.

The Proof Book is a compilation of evidence of the dependability of Hoyt leather belting in service, with a brief discussion of some of the fundamentals of belting economy. The illustrations are from actual installations, showing Hoyt belts in service over various periods up to 44 yr. A variety of difficult drives are pictured. Edward R. Ladew Co., New York City, is the manufacturer.

In Bulletin No. 46,017, second edition, old series 4879, published by the General Electric Co., are described medium-sized high-grade instruments for switchboards on direct-current circuits, legible scale, and the word "Amperes" or "Volts" is prominently marked on the dial for identification. Ammeters have internal shunts up to 60 amp., inclusive, and external, interchangeable special alloy shunts, practically zero temperature coefficient, up to 3000 amp., inclusive; voltmeters are self-contained up to 750 v.

The small, current-carrying coil is wound on a light cylindrical aluminum frame pivoted in jeweled bearings to move freely in a narrow annular space between a soft iron core and the pole pieces of a permanent magnet. The core, armature and bearings are removable from within the soft steel shell by loosening two screws. Meters are dustproof and protected from stray fields in a round cast-iron case, polished copper trimmed.

Scales are uniform and can be furnished to indicate current flow in two directions. Type D-7 measures 9½ in. with 6-in. scale; Type D-8 measures 7 in. with 4½-in. scale. Back-connected instruments, raised or flush, are standard, but front-connected can be furnished. Lists, various scales and dimension drawings are given.